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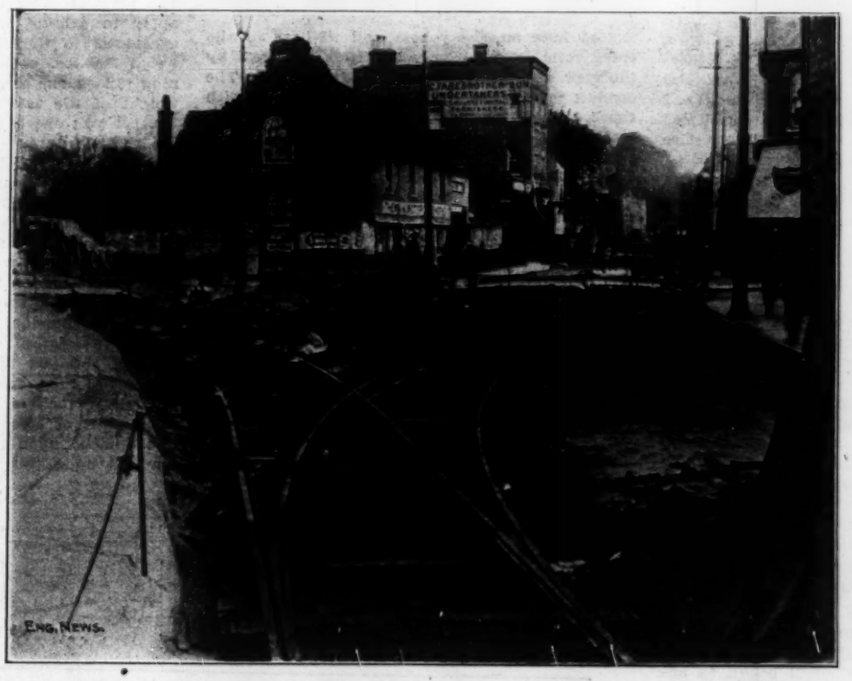
THE RAPID TRANSIT SYSTEMS OF LONDON.

The rapid transit facilities of the city of London, England, have been improved to a remarkable degree within the past few years, and afford a number of points of interest, especially in the handling of extremely heavy traffic distributed over large areas. A member of the editorial staff of Engineering News spent some weeks in London during the past summer, and from his notes and observations the following article has been prepared.

Owing to the many narrow and crooked streets, and the dense congestion of traffic in the main thoroughfares, and owing partly no doubt to a rather strong conservatism on the part of the local authorities, street railways have for years been excluded from the main part of the city and confined mainly to outskirts of the city proper and to the suburban districts. As a result of this, the cab and the omnibus have formed the principal means of urban transit within the business district, while the omnibuses also operated over long routes radiating to the numerous suburban districts. The old steam underground railways (now converted to electric traction) form a belt line around the central business district, but until within very recent years there were no railways inside this belt, the cabs and omnibuses forming almost the only means of transit within it. Three special features of the new developments are as follows: 1, motor omnibuses; 2, electric street railways; 3, underground railways.



STREET RAILWAY TRACK WITH STEEL TIES, LONDON AND RICHMOND ROADS.

MOTOR OMNIBUSES.

The rapid development of the private motor carriage or automobile has been accompanied, in Europe, by an important development of motor omnibuses for public service, and in London there are now hundreds of these latter machines in use. The great majority of them are operated by gasoline engines, and are double-deck machines, with a spiral stairway from a large rear platform to the roof. Fig. 1 shows a motor omnibus built for one of the London companies by the Brush Electrical Engineering Co., of Loughborough. This has seating accommodation for 16 inside (on longitudinal seats) and 18 outside (on transverse seats with a central gangway). The weight complete is 4¾ tons, and it is driven by a gasoline engine of 35 HP. One of the omnibus companies is operating several steam omnibuses of the Clarkson type, which were recently described at a meeting of the British Institution of Mechanical Engineers. Fig. 2 shows a plan and elevation of this machine, with the body removed.

In the Clarkson steam omnibus, the boiler is of a "semi-flash" water-tube type, having a series of dished spiral coils connected together to form the equivalent of a continuous length of tube. The feed water enters at the top, and after reaching the bottom the water (or wet steam) is led to a coil directly over the fire, and then up to the final or superheating coil. The steam pressure is from 300 to 450 lbs., and the pyrometer (mounted in front of the driver) indicates a steam temperature of about 800° F. The fuel is kerosene. A two-cylinder double-acting engine is used, having slide valves operated by the Joy valve gear; this drives the countershaft through a single set of spur gearing, and sprocket chains run from wheels on this shaft to sprockets on the rear driving wheels. The exhaust steam is condensed in a radiator placed in front of the machine and having vertical tubes, over which a stream of air is forced by a fan.

While the motor omnibuses are successful mechanically, there are a number of objections to them, most of which can be overcome by care and discipline. In the first place, many of them are very noisy, owing to neglect to maintain the mechanism in good condition, while the amount of vibration is astonishing. In some of the machines the noise and vibration are objectionable only to a slight degree, so that evidently the trouble is not insuperable. The most serious trouble, however, is the skidding of the wheels, which slide laterally on the paving (especially on wet or damp wood and asphalt), so that collisions and other accidents are frequent. In many cases the skidding is stopped only when the wheels strike laterally against the curb, and innumerable lamp posts have been knocked down by these machines when beyond control. During a period of some weeks in London last summer, the papers daily reported from two to half a dozen accidents due to the skidding of motor omnibuses. Numerous devices have been invented to prevent skidding and some of these have been tried, but many are impracticable and none have proved thoroughly successful. It is, of course, impossible to use projections, which would injure the paving. The devices include special forms of tires and also automatic sanders, which are put in operation when the lateral movement of the machine commences.

In spite of numerous defects, the motor omnibus has become one of the regular means of rapid transit in London.

The report of a Parliamentary committee appointed to investigate the conditions of vehicular traffic in London states that 320 motor omnibuses were licensed during the year, and 400 of these carried 1,500,000 passengers per week. The first machine of a given class is subject to inspection before the license is issued, but the report states that the duplicate machines should be similarly inspected, while when in service the omnibuses should be frequently and severely tested, especially in regard to the steering gear and the brakes. A legal speed limit of 12 miles an hour, actively enforced by the police, is also recommended. As to the skidding or side-slip of the machines, the report states that this is mainly due to: 1, a greasy or slippery road surface; 2, the mechanical action of the differential gear in propelling the driving wheels unequally under certain conditions. The liability to side-slip is greatly increased by the needlessly high camber of many roads. The danger can only be avoided by the provision of good road surfaces, kept in

proper condition, and by the substitution for the differential gear of a more efficient mechanism. The chief cause of noise and vibration is said to be unevenness of the road surfaces, and some reduction would result from the use of omnibuses of smaller capacity and decreased weight. The report points out that the police have authority to order off the street any licensed motor omnibus making an undue noise, causing a nuisance by the emission of smoke, or otherwise faulty. From Jan. 1 to June 8, vehicles were stopped 114 times for weak springs and broken frames; but the committee considered that the police should more rigorously exercise their powers to remove offending vehicles off the streets. To prevent offensive exhaust, whether due to the presence in the exhaust gases of carbon monoxide or to smoke caused by overlubrication, it is recommended that automatic ignition and automatic lubrication be included in the specifications of motor vehicles. It is also suggested that there should be a switch within the conductor's reach by which the current for ignition purposes can be interrupted, thus stopping the engine in case of emergency.

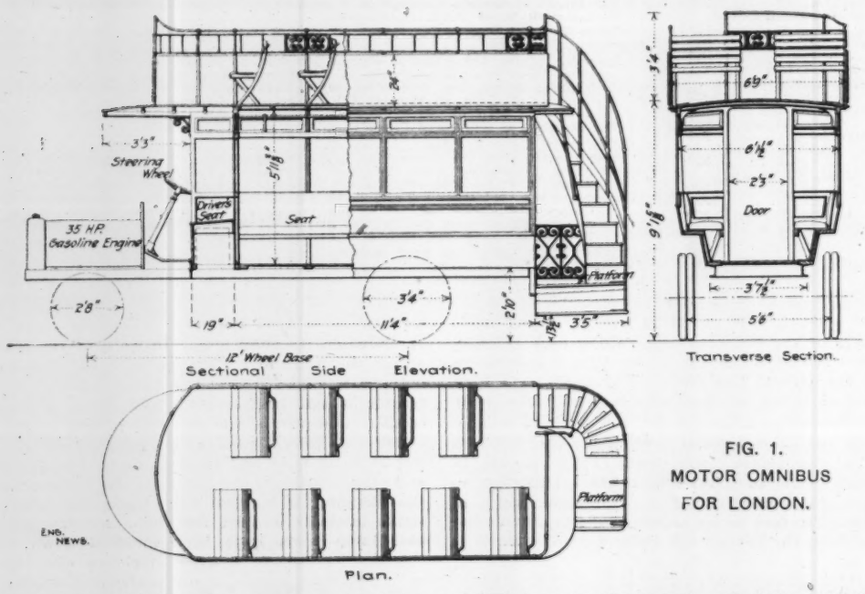


FIG. 1. MOTOR OMNIBUS FOR LONDON.

In connection with the use of passenger omnibuses, reference may be made to the very extensive use of motor wagons, steam wagons, and traction engines in the streets of London. Ponderous motor wagons with steam or gasoline engines are numerous, as are also traction engines hauling wagons; some of these are used by the local authorities for hauling garbage, water main and street repair outfits, etc. There are now about 1,200 heavy motor vehicles licensed in London, including omnibuses and wagons.

ELECTRIC STREET RAILWAYS.

All the street railway lines in London were operated by horses until within a few years ago, when the London County Council began to acquire many of these lines and to convert them to electric traction. At the present time there are numerous long electric lines, and the work of rebuilding the old lines and introducing electric traction is proceeding rapidly. The conduit system is adopted within the city and the more crowded districts, while the trolley system is used in the outlying districts. Some important contracts on this work have been executed by J. G. White & Co., of London, and we are indebted to Mr. Wm. C. Burton, Director of the firm, for information and photographs.

For the London County Council this firm has constructed nearly 60 miles of track. The first sections were laid entirely with short yokes carrying the slot rails only, as shown in the drawing of the track construction, Fig. 3. In later work, however, the alternate yokes are extended to carry the track rails, and this form of yoke is shown in Fig. 4. The short yokes weigh 176 lbs. and the long yokes 324 lbs. each. Where short yokes alone are used, the slot rails and track rails are both anchored to the yokes by tie-bars, as shown in Fig. 3, the tie-bars for the track rails having hooked ends to engage the projections on the yokes. Where the two styles of yokes are used, the slot rails have tie-bars to the alternate short yokes (the bars resting in slotted lugs on the yokes) and tie-bars to the track rails at the long yokes; this is shown by the view of work under construction, Fig. 5. The conduit is 14½ ins. wide and 17 ins. deep, with the bottom 24 ins. below the street surface. The tracks are of standard gage, and usually 9 ft. c. to c. They are laid with grooved girder rails 7 ins. high, of the British standard sections, weighing 102, 104 and 105 lbs. per yd. The rails are in lengths of 45 and 60 ft., and are laid with square joints (not on the yokes) spliced with 24-in. bars and six bolts. The rails are anchored in the concrete by having pieces of old rails inverted and riveted beneath the flanges, anchors being 7 ft. 6 ins. apart. They [illegible] also anchored by the Cooper anchor joint.

The concrete consists of 1 part Portland [illegible]ent and 6 parts of "ballast" (clean, coarse [illegible]avel and sand), and there are 1.95 cu. yds. [illegible]con-crete per lin. yd. of double track. [illegible]rete mixers of the dromedary type were first [illegible]sed, but at the present time no concrete mix[illegible]ma-chines are used. The concrete is [illegible] on boards immediately over the trench and [illegible]eled into it. The number of men employe[illegible]ries so much according to obstacles encounte[illegible] that no very definite figures can be given; [illegible]er-ing gangs, however, range from 20 upwa[illegible] and tracklaying gangs from 15 upwards. Th[illegible] aver-age rate of progress is about 500 to 60[illegible] per day, with a maximum of about 1,200 ft. [illegible]gs. 6 and 7 illustrate the construction of a [illegible]grade crossing of a conduit line with a railway [illegible]ding. As shown in Fig. 6, the yokes are of spe[illegible] sec-tion, extended to form long seats for I-beams which are fitted between them and carry the girder rails for the steam track. These I-beams are connected by transverse members supporting the rails of the electric line and forming a rigid framework. At the left are seen the ties of the siding, with their rail chairs in place; it will be noticed that these chairs are made to carry both a running rail and a guard rail. Fig. 7 shows the crossing ready for the track connections and the concrete.

The same company is now building two miles of conduit line on the side-slot system. This is the first construction of its kind in London, although some years ago the company built at Bournemouth the first side-slot line in England. The particulars of the conduit line given above apply in general to the side-slot construction, except as to the following points. The yokes weigh 200 lbs. each, and while the single running rail on one side weighs 105 lbs. per yd., the weight of the two rails forming the slot is 88 lbs. per yd.; one of these latter, of course, forms the second running rail. The running rails are laid with square joints, breaking joint with the slot rails. The continuous rail joint is used.

A double-track line on the conduit system was built along the Thames Embankment last summer to a shallow subway line. In watching this work, the writer was surprised to see all concrete mixing done by hand, but was informed that machine mixers are not used on this kind of work in London. The sand and gravel mixed (and quite damp) was delivered in two-wheel wagons, dumped upon a mixing platform laid across the rails, and measured by filling it into a large bottomless box laid upon the platform. Two sacks of cement were emptied into a box and dumped upon the gravel, and another sack emptied upon this, but on windy days an ap-

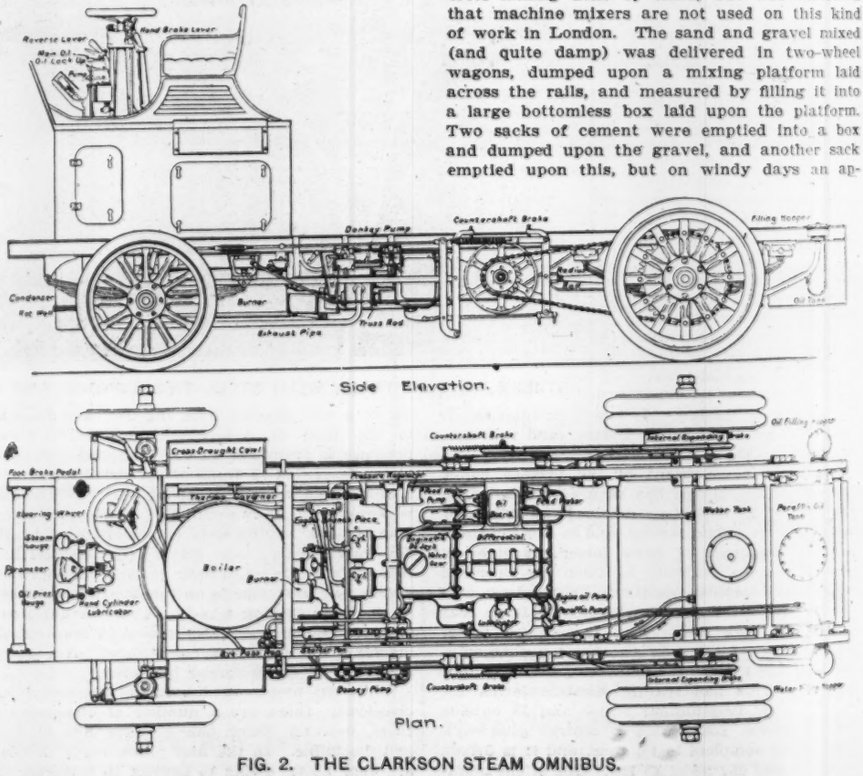


FIG. 2. THE CLARKSON STEAM OMNIBUS.

proportion of the cement was blown away, making the air cloudy with dust. The mixing box being removed, ten men (in two rows) then turned over the mixture and gradually passed it to the rear end of the platform; it was sprinkled from water cans to a fairly wet

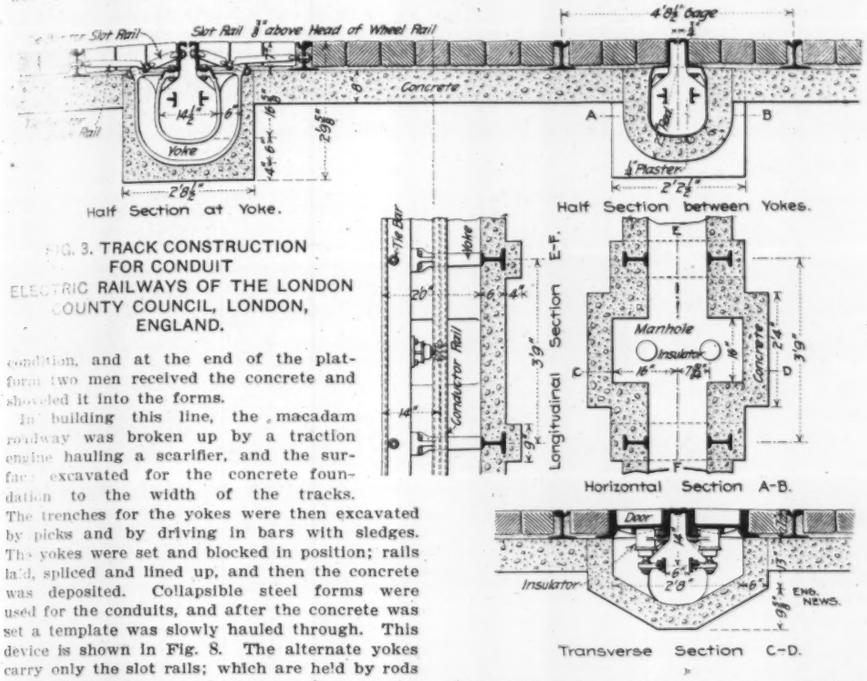


FIG. 3. TRACK CONSTRUCTION FOR CONDUIT ELECTRIC RAILWAYS OF THE LONDON COUNTY COUNCIL, LONDON, ENGLAND.

condition, and at the end of the platform two men received the concrete and shoveled it into the forms.

In building this line, the macadam roadway was broken up by a traction engine hauling a scarifier, and the surface excavated for the concrete foundation to the width of the tracks. The trenches for the yokes were then excavated by picks and by driving in bars with sledges. The yokes were set and blocked in position; rails laid, spliced and lined up, and then the concrete was deposited. Collapsible steel forms were used for the conduits, and after the concrete was set a template was slowly hauled through. This device is shown in Fig. 8. The alternate yokes carry only the slot rails; which are held by rods lying between lugs on the yoke and set up by nuts. The other yokes also carry the track rails, and here the slot rails are connected to the track rail by tie-rods. The tracks are laid at one side of the roadway, and in the same position across Westminster Bridge. The paving is of Australian wood blocks, but on some of the conduit lines in suburban districts granite blocks are used. This work was built by Dick, Kerr & Co., of London.

The London United Electric Tramways Co. Co. has 70 miles (single track) of electric line on the overhead trolley system, and 30 miles of the latest sections have been built by J. G. White & Co., of London. This, like all the London work, is notable for the substantial character of the construction. The tracks are of standard gage, 8 ft. 6 ins. or 9 ft. c. to c., and laid with 6½-in. 92-lb. grooved rails of the British standard section, the steel having 0.45 to 0.50% carbon. The rails are in lengths of 60 ft., and are laid with square joints, spliced with 24-in. plain splice bars and six bolts. The joints are made very rigid and are anchored to the concrete, the construction being shown in Fig. 9. Under the ends of the rails is a ½-in. steel plate 30 × 12 ins., and under this an 8-in. I-beam 30 ins. long. Six hook bolts on each side hold the three parts together, the bolts passing through holes in the rail base and plate and notches in the flanges of the I-beam; the hooks engage with the I-beam while the nuts are screwed down upon wedge-shaped washers on the rail base. Flat tie-bars with threaded ends are passed through the webs of the rails and secured by nuts; these are 6 ft. apart at joints and 6 ft. 6 ins. elsewhere. In addition to these, steel ties of old 6-in. 75-lb. grooved rails (inverted) are placed at intervals of 9 ft.; these are 6 ft. long and are bolted to the rails. The frogs and switches are of Allen manganese steel; the switch rails are 9 ft. 6 ins. long and 4 ins. deep, connected by a 1⅛-in. rod; No. 8 frogs are used. At all switches there are drainage openings to a 4-in. pipe drain. There are two copper bonds 32 ins. long at each joint, and the track is cross-bonded at intervals of 120 ft., while the two tracks are cross-bonded at 240-ft. intervals. A view of a portion of this line with its steel ties, being the junction at London Road and Richmond Road, is shown on p. 311.

The concrete is composed of 1 part Portland cement to 7 parts of "ballast," or gravel; and with tracks 9 ft. c. to c. there are 1.07 cu. yds. of concrete per yd. of double track. The concrete was not placed until after the tracklaying and bonding was completed, the surface of the concrete being afterwards finished by floating a 1½-in. coat to form the proper curve for the paving. The space between the rails and tracks and for 14 ins. outside the outer rails is paved with blocks of Australian jarrah wood, 9 × 3 ins., and 4½ ins. thick; these were dipped in hot pitch and laid with 4½-in. broken joints, and the finished paving was grouted with a 2 to 1 cement grout. A line of Scotch granite blocks, 6 to 9 ins. long, 4 ins. wide and 5 ins. deep, grouted with pitch and gravel, was laid along the edge of the wood paving. On long grades the street railways have cast-iron intercepting drains, with narrow grated openings across the paving; these divert the storm water into the sewers.

The poles are of steel, 33 ft. long, and are unusually heavy, as the span wires are 23 ft. above the rails, to allow of the use of double-deck cars. A grooved trolley wire is used. Current is obtained from the main power station of the London Underground Railway Co., at Chelsea, which station supplies several of the underground lines. Alternating current of 11,000 volts, 33⅓ cycles, is transmitted to a substation at Kingston, from which it is delivered to the trolley line as 500-volt direct current. The equipment consists of double-deck, double-truck cars. These seat 30 persons inside and 44 outside. Each car has two Westinghouse 40-HP. motors.

In the construction of the conduits for the line first mentioned, a collapsible steel form is used, which was patented by J. G. White & Co. and Isaac H. Fisher. This is shown in Fig. 11 and is adaptable also to the pockets, manholes, etc. It is composed of three metal sheets so shaped as to interlock at the longitudinal joints, and held in place by transverse diaphragms set up by wedges. These wedges can be withdrawn by hooks let down through the slot. The same hooks are then engaged with handles on the metal sheets, and these are removed through the slot.

Fig. 5. Conduit Electric Railway Under Construction.

Most of the London street railways use double-deck cars, both for horse and electric traction, and in most cases they are mounted on two trucks. One important line, operated by the London County Council, has cars without the usual upper deck on account of running for some distance through a shallow subway under the streets (Engineering News, July 12, 1906), and the Erith Urban Council, near London, uses four-wheel (or single truck) double-deck cars. The cars can as a rule pass curves of 30 ft. radius. Fig. 12 shows a large double-deck car of the London United Electric Tramways, having the upper deck enclosed and roofed in, except that at each end of the upper deck is an open space (with seats) for smokers. The trucks are of the Brill maximum traction type, with a 35-HP. motor to each truck. These double-truck cars were built by the United

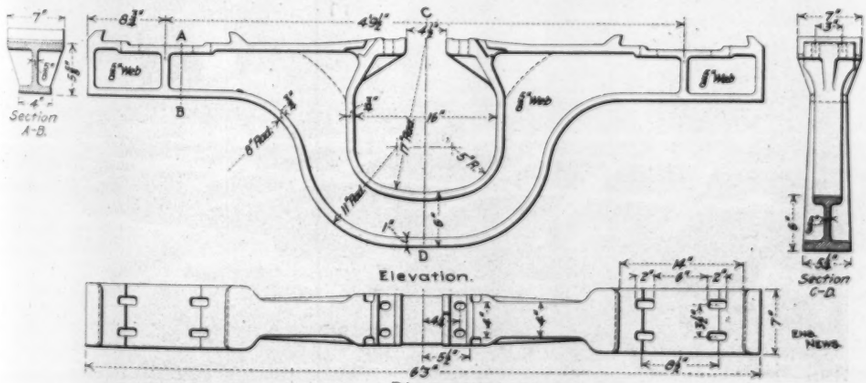


FIG. 4. EXTENDED YOKE FOR CONDUIT LINE.

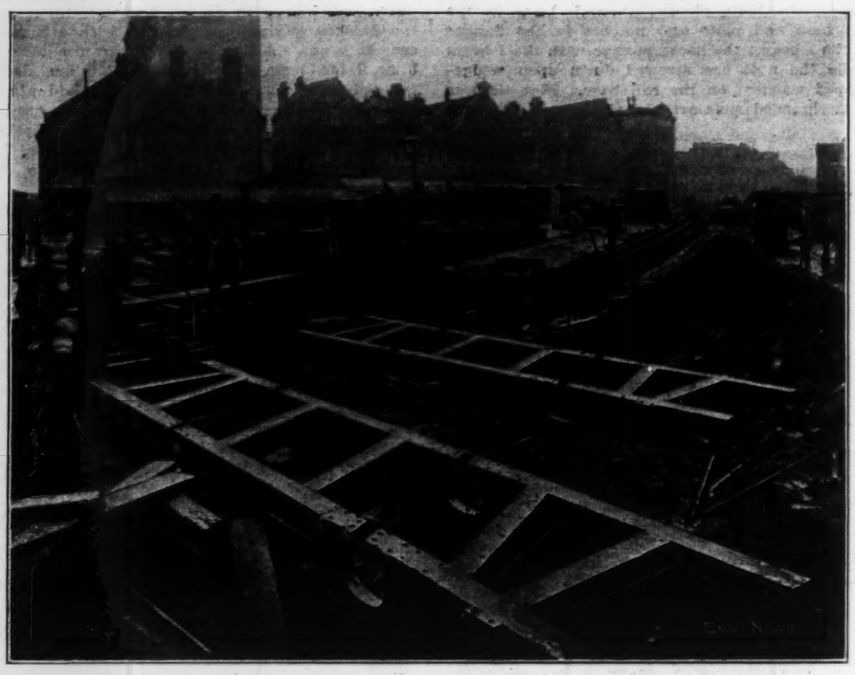


FIG. 6. FRAMEWORK FOR GRADE CROSSING ON CONDUIT LINE.

Electric Car Co., of Preston, England, while the single-truck cars above mentioned were built by the Brush Electrical Engineering Co., of Loughborough. The dimensions of the two types of cars are given in Table I.:

Table I. Double-Deck Electric Cars.

	Double-Truck.	Four-Wheel.
		Ft. Ins.
Length over body		16 0
Length over platforms	34 ft. 7½ ins.	27 0
Width, extreme	7 " 2 "	7 0
Height: Inside lower deck.		6 9
Inside upper deck		5 8½
Rail to floor		2 6¾
Rail to top of roof		15 7
Wheels, diameter	1 ft. 9 ins. and 2 ft 7½ ins.	2 7
Wheelbase, truck	4 ft. 0 ins.	6 0
Wheelbase, total	17 " 6 "	6 0
Weight, complete	10¾ tons	8½ tons
Passengers, lower deck	30	22
Upper deck	44	*36
Total	74	48

*Eight outside.

UNDERGROUND RAILWAYS.

The first piece of underground railway in London was opened in 1863. The original system formed an irregular belt line, with numerous connections to main line railways and with a number of surface suburban extensions. This has been in operation for many years, and consists of arched tunnel and rectangular subway (cut and cover) construction kept as near to the surface as possible. Its location is shown in Fig. 13. The northern portion is owned by the Metropolitan Ry. and the southern portion by the Metropolitan District Ry., but it is operated as one system, the trains of each company passing over both portions. It was originally operated by steam locomotives, but these have now been superseded by electric traction.

For many years projects were promoted for underground lines traversing the district enclosed by the original system, but none of these materialized, until a few years ago the Central London Ry. was authorized to build and successfully completed an east and west diametrical line. This was a deep-level tubular tunnel line, but as a type it had been preceded by the City & South London Ry. and the Waterloo & City Ry., each extending under the Thames from the central part of the city southward. Both have been succeeded by a number of other lines, several of which have been completed recently, so that there is now a network of deep level "tube" lines, all operated by electricity. Unfortunately, the lines have not been laid out as part of a comprehensive scheme, but each one has been promoted by an independent concern with a view to a certain route or direction of traffic, so that the system is not as comprehensive or homogeneous as it might have been. Connections are made by passages, shafts, etc., at several points where

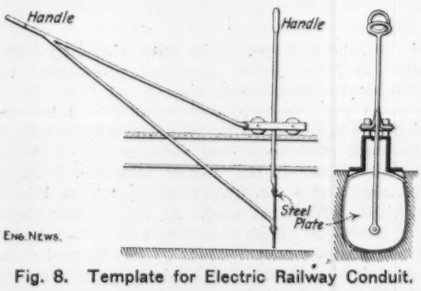


Fig. 8. Template for Electric Railway Conduit.

the lines cross, but in many cases these involve long walks on level or inclined subways, and the climbing of spiral stairways. Elevators are used at the stations, but for some reasons they are often placed at a distance from and do not reach the level of the station, so that passengers have to use a combination of elevators, stairs and passages in getting from the street to the platform. The elevators are of insufficient capacity to promptly handle the rush traffic, and streams of people then use the stairways to the surface. In several cases also, the passages are narrow, or their arrangement is awkward, so that the streams of passengers going to and from the trains are congested or "throttled," or even conflict with one another. Long underground passages or subways lead from the stations to important points (such as railway terminals, etc.) so that passengers can reach them without crossing the streets. At "The Bank," where numerous streets and lines of traffic center, there is a circular subway just below the street level, with stairways to the several streets, so that the general public as well as the railway passengers can get from point to point without crossing the streets. In the center of this subway is the entrance to the shaft of the terminal station of the Central London Ry., with connections to stations of other underground lines.

A map of the underground railway system is shown in Fig. 13, and some particulars of the several lines are given in Table II. and in the accompanying notes.

METROPOLITAN RY. AND METROPOLITAN DISTRICT RY.—These lines are at present in a transitory state, being converted from steam to electric traction, and have three systems of traction now in use on the same tracks: 1, the electric trains of the two companies; 2, suburban trains from other lines hauled by steam locomotives; 3, suburban trains from other lines which detach their steam locomotives at the connection with the "underground," and are hauled over the latter by electric locomotives. Eventually all the steam locomotives will be abandoned for tunnel service, except perhaps for the freight trains handled by some of the main line railways over parts of the underground lines to reach local terminals in the city. Some of the regular trains of the Metropolitan Ry. consist of seven double-truck compartment cars, each of the two end cars having four motors of 200 HP. The motor cars also have baggage compartments. The trains have the Sprague multiple-unit control system, and can be run at 45 miles an hour, the average schedule speed (including stops) being 16 miles per hour. The motor cars weigh about 38 tons each and the trail cars 19 tons each, with a total weight of

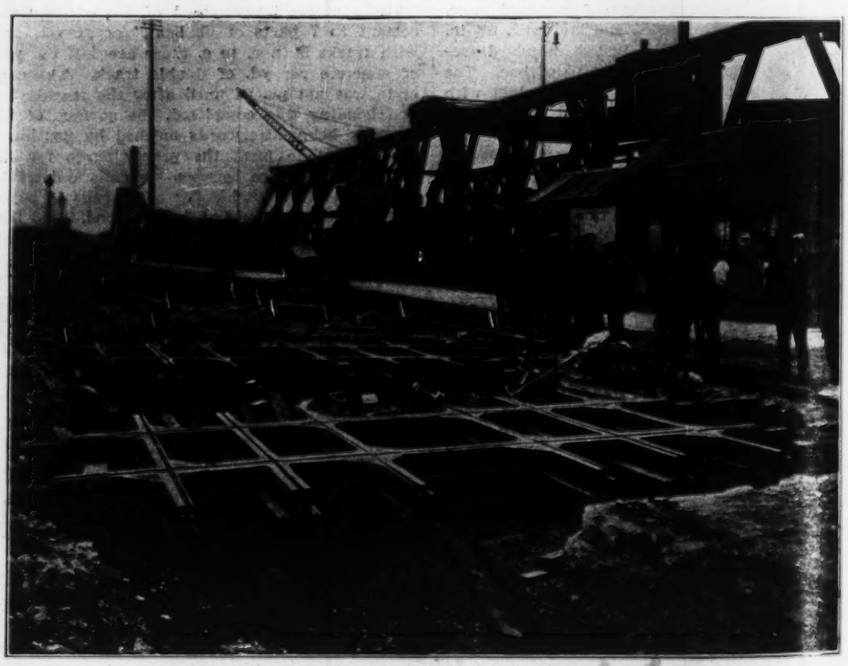


FIG. 7. GRADE CROSSING WITH RAILS IN POSITION.

FIG. 12. DOUBLE-DECK ELECTRIC CAR FOR THE LONDON ELECTRIC RAILWAYS.

172 gross tons for the train, which is 290 ft. long. The train has seats for 120 first-class and [illegible] second-class passengers. The cars are 11 ft. 6 ins. high over all, mounted on steel-frame trucks with 38-in. steel wheels, 6½-in. axles and 7-ft. wheelbase. They are equipped with automatic quick-acting air brakes. The under-

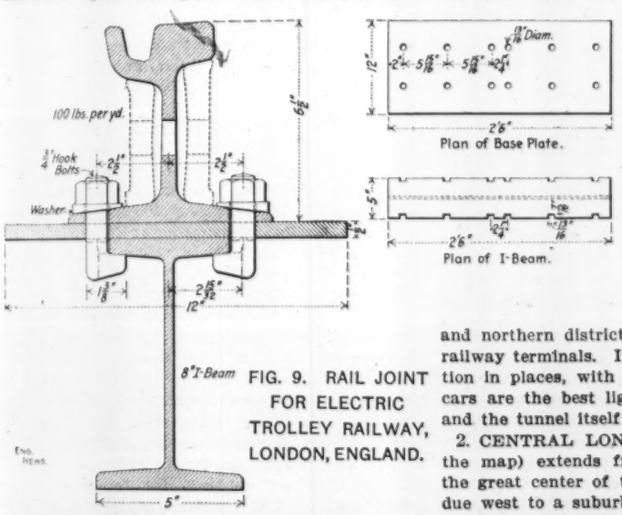


FIG. 9. RAIL JOINT FOR ELECTRIC TROLLEY RAILWAY, LONDON, ENGLAND.

frames are of 9-in. channels, and the floor has a ½-in. sheeting of uralite on the underside, and a ¾-in. cement surface. All wires and cables of the car equipment are enclosed in steel tubing.

1. BAKER ST. & WATERLOO RY.—This is one of the newest of the tube lines, and was described in our issues of Aug. 2 and Sept. 6, 1906. It extends from a point known as the "Elephant and Castle" (after an inn famous in the days of stage coach traveling) under the River Thames and then north and west, connecting southern and northern districts and serving a number of railway terminals. It has a very circuitous location in places, with much sharp curvature. Its cars are the best lighted of any of these lines, and the tunnel itself is well lighted.

2. CENTRAL LONDON RY.—This (No. 2 on the map) extends from the Bank of England, the great center of the business district, almost due west to a suburban district. The track has shallow rails on timber longitudinals, and the joints are very noisy. It was originally operated by electric locomotives, but these, in combination with the track construction, caused so much vibration on the ground surrounding the tunnel as to start numerous damage suits, and the motor-car system has been substituted. The line is ventilated from one end, and from 1 a. m. to 4 a. m. (when there is no traffic) special doors are closed across openings at intermediate stations, so as to give a direct draft throughout the entire length of the line. The results are only partially satisfactory. This is the only line to adopt the American system of uniform fares; the fare is 4 cts. (two-pence) and the line is popularly known as the "tuppeny-tube."

3. CHARING CROSS, EUSTON & HAMPSTEAD RY.—This line is on a route which has been covered by projects innumerable during over 30 years, the purpose being to provide a badly needed cross-town line and to connect important northern and southern railway terminals. It furnishes a direct line between the Charing Cross terminal of the Southeastern & Chatham Ry. and the Euston terminal of the London & Northwestern Ry., and then extends north to residence districts. It will be opened in a few months, and is owned by the London Underground Ry. Co., which also owns the Baker St. & Waterloo Ry. (No. 1) and the Great Northern, Piccadilly & Brompton Ry. (No. 6).

4. CITY & SOUTH LONDON RY.—This road now extends from Clapham in the south to the heart of the business district and to three im-

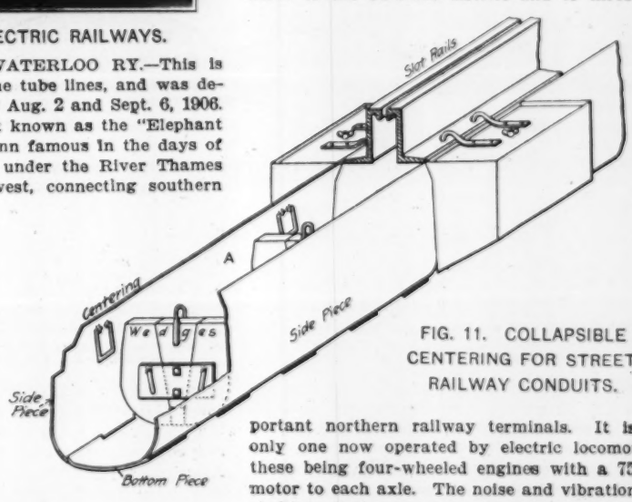


FIG. 11. COLLAPSIBLE CENTERING FOR STREET RAILWAY CONDUITS.

portant northern railway terminals. It is the only one now operated by electric locomotives, these being four-wheeled engines with a 75-HP. motor to each axle. The noise and vibration and shaking of the cars are very objectionable, and the air is generally very stuffy, causing headache and a feeling of oppression. There are no lights in the tunnel. The cars are small, fitting close to the tunnel, and have side seats; they are very dimly lighted. There is a single platform between each pair of cars, covering the couplings, and this arrangement enables a wide gate to be used, facilitating the movements of passengers. The track has T-rails on wooden ties, and the rails show signs of corrugation to a remarkable extent.

5. GREAT NORTHERN & CITY RY.—This road is peculiar in having the tunnels large enough (16 ft. diameter) to take ordinary rail-

TABLE II. UNDERGROUND RAILWAYS OF LONDON, ENGLAND.

Railway	Shallow Lines: Metropolitan	Shallow Lines: Met. Dist.	Deep-Level Tube Lines: Baker St. & Waterloo	Cent. London	Ch. Cross, E. & Hamp.	City & So. London	Gt. Nor. & City	Gt. Nor., P. & Brompton	Waterloo & City
Opened	Jan., 1905*	July, 1905*	March, 1906	July, 1900	(1907)	Dec., 1890	Feb., 1904	Dec., 1906	Aug., 1898.
Length of line, miles	26	41.0	5.25	6.5	8.0	6.25	3.42	9.0	1.5
Length of track, miles	59	80.5	11.50	13.0	16.5	12.25	7.75	18.5	3.0
Diam. of tunnel	25 ft. and 28 ft. 6 ins. wide		11 ft. 8¼ ins.	11 ft. 6 ins.	11 ft. 8 ins.	10 ft. 6 ins.	16 ft. 0 in.	11 ft. 8 ins.	12 ft. 0 in.
Conductor system	3 and 4 rail	3 and 4 rail	3 and 4 rail	3d rail	3 and 4 rail	3d rail	3 and 4 rail	3 and 4 rail	3d rail
Max. grade	1 in 44	1 in 40	1 in 60	1 in 30	1 in 33	1 in 30	1 in 52	1 in 33	1 in 30
Min. curve	363 ft.	330 ft.	330 ft.	.....	330 ft.	120 ft.	660 ft.	330 ft.	320 ft.
Track rail, wt. per yd.†	B. 86 lbs.	B. 86 lbs.	B. 90 lbs.	Bg. 100 lbs.	B. 90 lbs.	T. 80 lbs.	T. 85 lbs.	B. 90 lbs.	B. 87 lbs.
Conductor rail, wt. per yd.‡	T. 100 lbs.	T. 100 lbs.	S. 85 lbs.	C. 85 lbs.	S. 85 lbs.	C. 40 lbs.	C. 80 lbs.	S. 85 lbs.	C., 46 lbs.
Joint bonds, total sec.	1.5 sq. ins.	1.4 sq. ins.	1.4 sq. ins.	0.31 in. track; 0.62 in. cond'tr	1.4 sq. ins.	0.33 sq. in.	0.6 sq. in.	1.4 sq. ins.	1.5 sq. ins.
Distribution, voltage	11,000	11,000	11,000	5,000	11,000	500, 1,000 & 2,000 D. C.	D. C.	11,000	D. C.
Power plant	14,000 KW.	¶	¶	5,100 KW.	¶	3,250 KW.	3,440 KW.	¶	1,350 KW.
Sub-stations	9	15	3	4	5	2	.....	5	0
Motor cars	55	234	36	68	60	52 el. locos.	35	72	17
Trail cars	112	236	72	150	90	142	45	144	12
Motors, per car	(4) 150 HP.	(2) 200 HP.	(2) 200 HP.	(2) 125 HP.	(2) 200 HP.	(2) 75 HP.	(2) 125 HP.	(2) 200 HP.	(2) 80 HP.
Car. acid gas in cars‖	14.07	11.27	.....	7.04	.....	11.78	2.35	.....	.....
Car. acid gas in street	1.75	3.55	.....	1.75	.....	3.55	1.75	.....	.....
Temp. during test, F.	74°	76°	.....	72¼°	.....	74°	68°	.....	.....
No. of stations	.....	.....	.....	13	.....	13	6	.....	.....
Fan ventilation	No	No	Yes	Yes	.....	No	Yes	19 fans	.....

*Electric traction introduced.
†Track rails: B. = bullhead section; Bg. = bridge section; T. = tee section.
‡Conductor rails: T. = tee section; S. = square section; C. = channel section.
¶Current purchased from the Underground Electric Railway Co.
‖Carbonic acid gas; parts in 10,000 volumes.

way cars. It extends from a northern residence district to the Bank of England, and was built with a view to the future possibility of the Great Northern Ry. running a suburban service in connection with this line, by means of an incline at the Finsbury Park terminal of the tunnels. The track is laid with T-rails on longitudinal timbers, with shoulder tie-plates and screw spikes. The timbers rest on concrete benches with a deep drainage trench between them, and are braced at intervals by transverse timbers. The cars are roomy and in general comfortable, but in some the seats are very narrow. The lighting is very irregular, and dim.

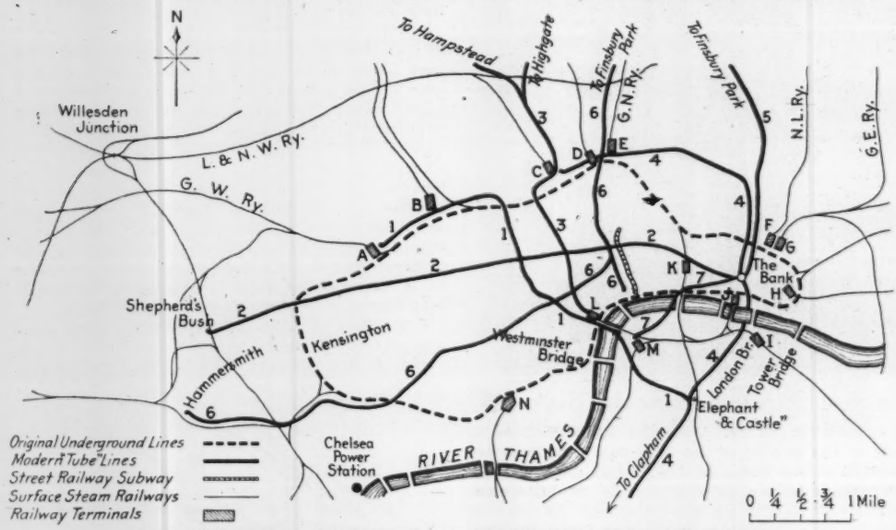


FIG. 13. MAP OF THE UNDERGROUND RAILWAY SYSTEM OF LONDON.

Underground Railways:
1. Baker St. & Waterloo Ry.
2. Central London Ry.
3. Charing Cross, Euston & Hampstead Ry.
4. City & South London Ry.
5. Great Northern & City Ry.
6. Great Northern, Piccadilly & Brompton Ry.
7. Waterloo & City Ry.

Railway Terminals.
A. Great Western Ry. (Paddington).
B. Great Central Ry. (Marylebone).
C. London & Northwestern Ry. (Euston).
D. Midland Ry. (St. Pancras).
E. Great Northern Ry. (King's Cross).
F. North London Ry. (Broad St.).
G. Great Eastern Ry. (Liverpool St.).
H. London, Tilbury & Southend Ry. (Fenchurch St.).
I. London, Brighton & South Coast Ry. and Southeastern & Chatham Ry. (London Bridge).
J. Southeastern & Chatham Ry. (Cannon St.).
K. Southeastern & Chatham Ry. (Holborn).
L. Southeastern & Chatham Ry. (Charing Cross).
M. London & Southwestern Ry. (Waterloo).
N. London, Brighton & South Coast Ry. and Southeastern & Chatham Ry. (Victoria).

6. GREAT NORTHERN, PICCADILLY & BROMPTON RY.—This is the longest and latest of the "tube" lines, having been opened on Dec. 15, 1906. It connects west-end and northern suburban districts and also serves important business, shopping and other districts. A short branch runs to the important thoroughfare known as the "Strand." A description was given in our issue of Jan. 10, 1907.

7. WATERLOO & CITY RY.—This was built to connect the Waterloo terminal station of the London & Southwestern Ry. (on the south side of the Thames) with the center of the city. The cars are small and close, and on the motor cars the floor is raised at the ends to clear the trucks. The tunnels are 12 ft. diameter.

The ventilation is not satisfactory on any of the tube lines, the best conditions being in the large tunnels of the Great Northern & City Ry. In all the others (and even in these to some extent) headache and an oppressive feeling in the chest and head are liable to be experienced, sometimes to a very unpleasant extent. On all these lines the problem is to secure efficient ventilation without producing currents so strong as to blow passengers' hats off or severe drafts that will cause passengers to take cold. The lighting of the cars is also very unsatisfactory as a rule; in general it is dim, and in all cases subject to fluctuations which are very trying. As people persist in reading during their journeys, the "tube" lines are likely to bring plenty of business to the oculists and opticians, unless the car lighting arrangements are very materially improved. The cars on different lines have side seats, cross seats, or a combination of both as in the cars of American rapid transit lines. In very few of them can the windows be opened, as open windows would be dangerous with such small clearance between the car and the side of the tunnel. In a few trains the cars are divided into compartments, but as a rule they are of the American type, with end doors. In some cases, side doors are also placed at the middle of the car. A unique arrangement on the City & South London Ry. consists in placing a single platform between each pair of cars, giving one wide opening for passage to or from the station platform. As a rule there is only one class, but on some of the lines the trains have first-class and second-class cars. One excellent feature is the cleanliness of the cars; there is practically no expectoration in the ordinary cars, and very little in the smoking cars, the latter even having "anti-spitting" signs. Tickets are issued to passengers, and given up to collectors as passengers leave the station platforms at their destinations. On the Central London Ry., with a uniform 4-ct. fare, the tickets are dropped into a [illegible]-box before the passengers go to the tra[illegible] as in American practice.

Some of the cars are shown in Figs. [illegible] 17. Fig. 14 is a view of one of the motor ca[illegible] f the Great Northern & City Ry., having tun[illegible] 6 ft. diameter; Fig. 15 is an interior view sh[illegible] the arrangement of the transverse seats ([illegible] fixed backs) and the side and end doors. Th[illegible] is an oil lamp at each end, while on either si[illegible] f the doorway is a list of the stations. Fig. [illegible] hows a motor car of the Waterloo & City Ry[illegible] aving tunnels 12 ft. diameter. The steel fra[illegible] are dropped between the trucks, and the sea[illegible] the ends of the cars are reached by steps. [illegible] 15 gives a plan and cross-section of one [illegible] these cars. The trail cars have level floors. T[illegible] cars for these two roads were built by the [illegible]nited Electric Car Co., of Preston, England, and their dimensions are given in Table III. All [illegible] them have Westinghouse air brakes and hand [illegible]rakes. The Brush Electrical Engineering Co., of Loughborough, has also built some rather larg[illegible] cars for the Great Northern & City Ry.; these have a wheelbase of 40 ft. 7 ins., and seat 60 passengers in the motor car and 64 in the trail cars; they weigh 19½ and 17¾ tons, respectively.

TABLE III. Cars of London Underground Railways.

	Gt.N. & City Ry.		Waterloo & City Ry.			
	Mot. Car.		Mot. Car.		Trail Car.	
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.
Length over platforms.....	49	6	47	0	46	3½
Width over all.....	9	4	8	9	8	6
Height above rail	13	6	9	8	9	7½
Wheels	3	0	2	9	2	6
Truck wheelbase	6	1	6	0	5	6
Total wheelbase	34	6	31	0	31	0
	Tons.		Tons.		Tons.	
Weight (without motors)..	19½		19¼		15¾	
Passengers	54		50		56	
No. and HP. of motors....	(4) 75 HP.		(4) 75 HP.		....	

A STATE WATER SURVEY OF ILLINOIS.

A water survey of Illinois has been in progress since 1895. The work, which has for its object "a chemical and biological survey of the waters of the State," was under the direction of Prof. A. W. Palmer until his death, in February, 1904, and since then it has been in charge of Prof. Samuel W. Parr, who also succeeded Professor Palmer as Professor of Applied Chemistry at the University of Illinois. Up to Jan. 1, 1906, 13,873 samples of water had been received by the Survey for analysis, including 5,376 sent by private citizens or local health officers, and 2,800 sent by the Sanitary District of Chicago—the latter in 1899 and 1900. The board has issued several reports, the latest being for the year ending Aug. 31, 1906. This report was prepared by Edward Barto and published as a bulletin of the University of Illinois (Water Survey Series, No. 3). The State Water Survey and the State Board of Health are now cooperating in the study of the water problems of Illinois, under the four subdivisions (1) Epidemics, (2) Sewage Purification, (3) Water Supplies, and (4) Streams. In case of epidemics it is understood that the State Board of Health will investigate "places where the typhoid rate is high," and that the Survey will analyze samples sent to it by the inspector of the Board. As to sewage purification, it is proposed that either one body or the other shall make "at least an annual inspection of all sewage works and sewerage systems, public and institutional." Regarding water supplies, the report indicates that "sanitary and economic analyses should be made at regular intervals of all supplies." No work relating to streams has yet been taken up. Under the direction of Mr. Jacob A. Harman, Sanitary Engineer of the State Board of Health,

FIG. 14. MOTOR CAR OF THE GREAT NORTHERN & CITY RY. (UNDERGROUND).

FIG. 15. INTERIOR OF CAR OF THE GREAT NORTHERN & CITY RY.

"a series of tests of the septic tanks of Champaign, Urbana and Lake Forest have been carried on. Sewage and effluent have been collected from the sewage disposal works at Monmouth, South Bartonville and Quincy. . . . negotiations are now under way looking toward the control of the Urbana septic tank" by the Survey and the Board. The report states that

it is proposed to run this septic tank in a way to attain its highest efficiency, with the hope of producing a model for other cities, institutions, or manufacturers who plan to install sewage disposal works. It is also hoped that this may lead to the foundation of a sewage experiment station, to be under the joint control of the State Water Survey, State Board of Health and the Department of Municipal and Sanitary Engineering of the University of Illinois. Such an experiment station has been founded at the Massachusetts Institute of Technology, and valuable results are being obtained. Our conditions differ, however, in the character of the sewage and in the character of the streams into which disposal works effluent is allowed to flow. We therefore believe that it will not only be profitable, but necessary for the State of Illinois to carry on experiments with sewage disposal. Many important cities of the State must obtain their water supply from surface waters, and such work will be of great value for the protection of the streams and lakes.

An agreement for a cooperative survey of the natural waters of Illinois during the year ending June 30, 1907, was made on July 1, 1906, between the State Water Survey and three other official bodies. The various bodies and the sums which each agreed to contribute are as follows: A total expenditure of $8,200 was provided for, the United States to contribute $3,000, the State Water Survey $3,200, the University of Illinois and the State Geological Survey $1,000 each. A provisional allotment of the $8,200 was made as follows:

Mineral Analyses:	
Surface waters	$1,830
Ground waters	1,300
Boiler waters	1,600
Sanitary Analyses:	
Surface waters	1,000
Ground waters	900
Experimental Work Upon Treatment of Water	1,000
Incidentals and Equipment	570
Total	$8,200

THE PASSAIC VALLEY SEWAGE DISPOSAL BILL, noted on page 275 of our issue of March 7, has passed both branches of the New Jersey legislature. It is understood that it will be approved by the governor.

PACKING MACHINERY FOR EXPORT is discussed at some length by Mr. Paul Roux, a member of the American Chamber of Commerce of Paris, in an article printed in "Daily Consular and Trade Reports" for March 14, 1907 (U. S. Department of Commerce and Labor, Washington, D. C.). The object of the discussion, as stated, is "to facilitate commercial transactions between the United States and France." As the report mentioned can be secured on application, it is only necessary to say further that it takes up in succession the preparation of machines for shipment, maximum weight and freight charges, dismounting fragile projections, protection of finished parts from damage and rust, construction of cases, customs examination, lists and drawings, and exterior marks.

EXTRACTION OF TURPENTINE FROM WASTE PINE BY STEAM.

What bids fair to be the opening up of a new industry is the extraction of turpentine from saw mill waste or from tree stumps, by a steam process. The stumps, for example, can be procured at small expense from cut-over lands and after the turpentine has been extracted, the refuse can be used for fuel in local power plants. The cost of turpentine procured in this way from saw-mill waste by the Florala Saw Mill Co., at Paxton, Fla., is less than 30 cts. per gallon.

The saw-mill waste is first passed through a hog, and together with the saw-dust, is carried on a conveyor chain through the upper part of a turpentine still, the dust being automatically dropped into the open retorts. After these retorts are filled they are securely closed, and steam is turned on, extracting the crude turpentine in about an hour. The turpentine passes into a tank with the condensed steam, the oil rising to the top and being partly cleaned during the process. It then goes through another still and from this through a cooling worm which lowers its temperature and thus prevents evaporation. Passing from the cooler, it goes through a series of vats, which thoroughly cleans it from impurities.

The company mentioned claims that more pure turpentine per cord of wood is obtained by its process than by any other now in operation; in addition, the value of the wood for fuel is not destroyed. This company has a six-retort plant with tank, still, cooling-worm, boiler, engine, 8-in. hog, Jeffrey conveyors, etc., and from its mill refuse turns out about 79 barrels of 52 gallons each per month. The mill is cutting about 75,000 ft. of lumber per day, or 2,000,000 ft. per month. Thus the product is about a gallon of turpentine from the waste from 500 ft. B. M. of output.

Arrangements are being made by the same company to experiment with a stump-puller and also with a machine for sawing tops from fat stumps on cut-over land. With these machines in operation its turpentine plant will be able to run nights and dispose of the surplus fuel to a near-by power plant. According to figures supplied us by this company, saw-mill dust will yield from 5 to 10 gals. of turpentine per cord, fat lightwood from 15 to 20 gals., pine stumps, 20 to 30 gals., and fat tops from 30 to 35 gals.

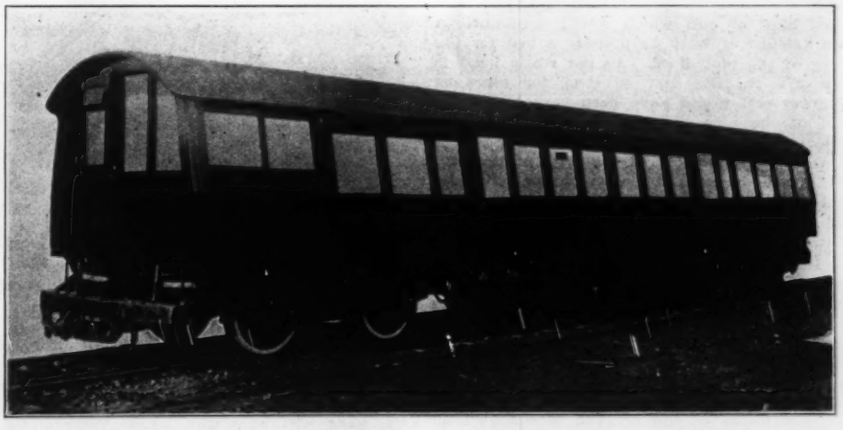


FIG. 16. MOTOR CAR OF THE WATERLOO & CITY RY. (UNDERGROUND).

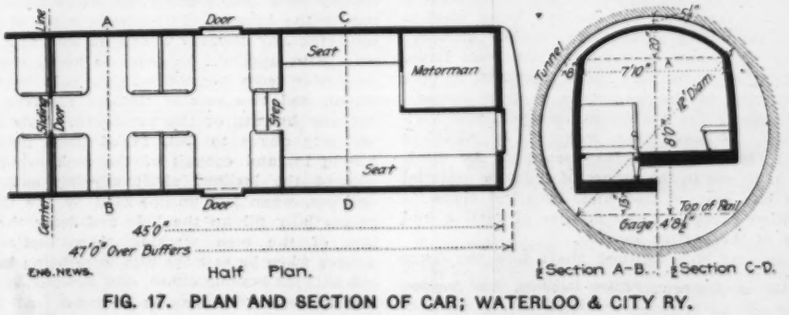


FIG. 17. PLAN AND SECTION OF CAR; WATERLOO & CITY RY.

THE CAVE-IN OF AN INCLINED SHAFT AND SUBSEQUENT RESCUE OF AN ENTOMBED MINER, AT BAKERSFIELD, CAL.

By F. C. FINKLE.*

In order to understand the causes leading up to the caving of the shaft which caused the death of five miners and the imprisonment of another for more than two weeks, it is necessary to understand the nature of the work in hand, and the plans for its construction.

The Edison Electric Co., of Los Angeles, wished to construct at Bakersfield, Cal., a pipe line to carry water from the top of a mountain to a power plant some 900 ft. below on the banks of the Kern River. When designing the power

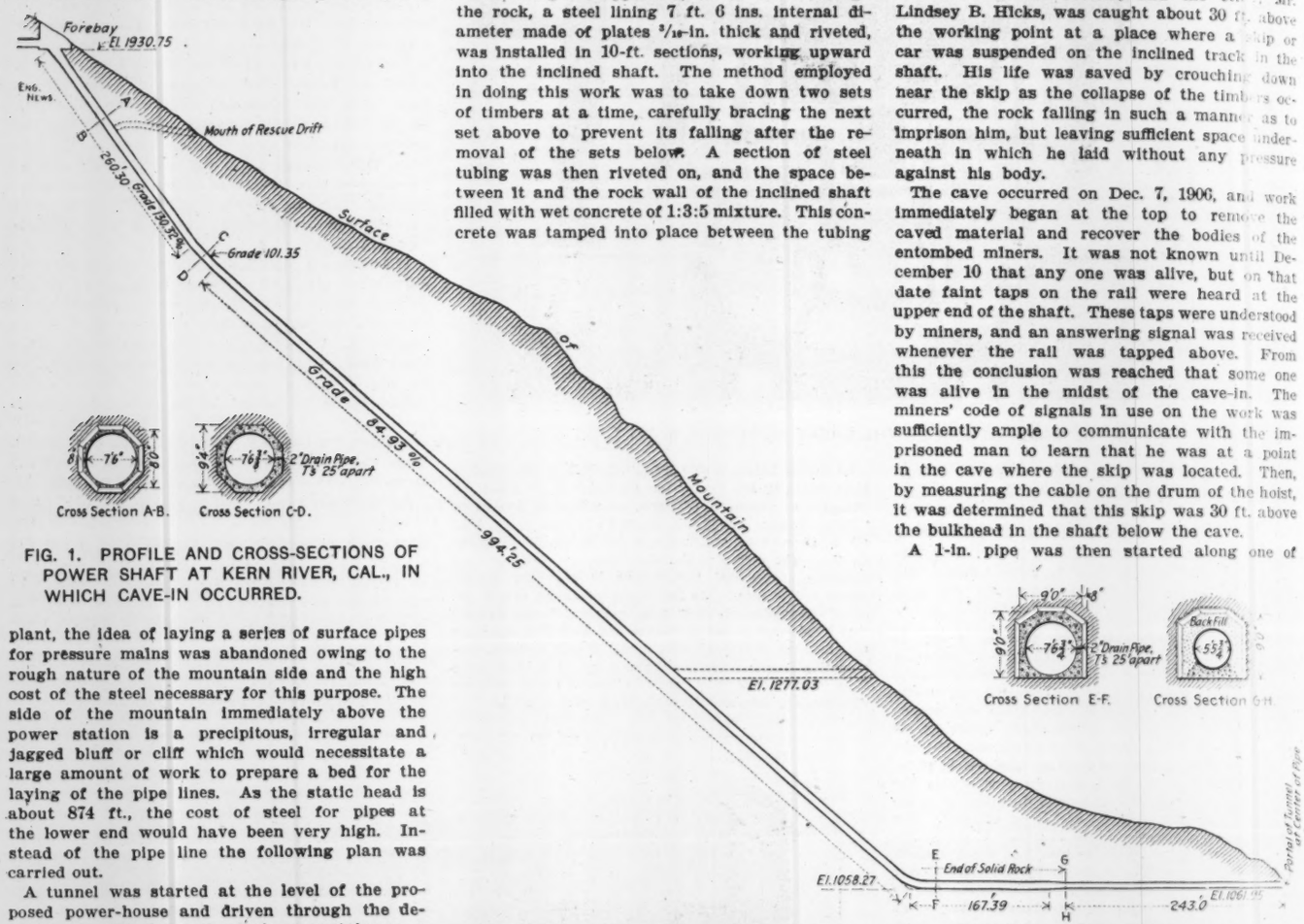


FIG. 1. PROFILE AND CROSS-SECTIONS OF POWER SHAFT AT KERN RIVER, CAL., IN WHICH CAVE-IN OCCURRED.

plant, the idea of laying a series of surface pipes for pressure mains was abandoned owing to the rough nature of the mountain side and the high cost of the steel necessary for this purpose. The side of the mountain immediately above the power station is a precipitous, irregular and jagged bluff or cliff which would necessitate a large amount of work to prepare a bed for the laying of the pipe lines. As the static head is about 874 ft., the cost of steel for pipes at the lower end would have been very high. Instead of the pipe line the following plan was carried out.

A tunnel was started at the level of the proposed power-house and driven through the detrital cone at the foot of the mountain on a gradual slope upward until a safe depth was penetrated into the bed rock of the bluff. At this point, shown in Fig. 1, the upward curve was made, starting the incline also shown on the profile. The incline was then driven and timbered, the ground not being sufficiently compact to be safe without timbering.

It was driven from both ends, the sinking being in progress at the forebay and stoping from below. The size of the bore for this incline was 8 ft. net inside of the octagon sets shown on Fig. 1. The nature of the ground is a metamorphic schist and syenite. The formation is very much fractured and cracked, being what is termed in mining phraseology "blocky ground." Few of the seams in the formation were large, and most of them were mere fractures, leaving the surfaces of the fragments in close contact. The necessity for timbering, however, was very apparent, although the material is what is termed "bed rock" in every sense of the word. None of it was in the nature of slides or material which has been shifted and disturbed since its deposition except by the process of folding and tilting of the earth's surface.

To convert this inclined shaft into the force main, it was planned to lay heavy steel pipe, braced against the bed rock and projecting through the tunnel into the detrital fill below. This pipe at the lower end where the bed rock did not exist was made sufficiently heavy to withstand the internal hydraulic pressure due to the static head of the water, with a factor of safety of five.

In preparing the shaft, the force main work was commenced at a point where the horizontal tunnel intersects the inclined shaft, and the two were joined by means of a vertical curve as indicated on the plans. A bulkhead was installed at this point around the heavy pipe, and work begun in both directions.

For lining the upper end of the shaft through the rock, a steel lining 7 ft. 6 ins. internal diameter made of plates $^{3}/_{16}$-in. thick and riveted, was installed in 10-ft. sections, working upward into the inclined shaft. The method employed in doing this work was to take down two sets of timbers at a time, carefully bracing the next set above to prevent its falling after the removal of the sets below. A section of steel tubing was then riveted on, and the space between it and the rock wall of the inclined shaft filled with wet concrete of 1:3:5 mixture. This concrete was tamped into place between the tubing and the walls of the shaft, up to a point within 18 ins. of the upper end of the section of tubing.

Temporary bulkhead timbers were then placed over the end of the pipe section, two more sets of timbers removed as before, another section of tubing riveted on and the concrete put in place as stated.

The work had progressed from the lower end up to a distance of approximately 1,700 ft., leaving only 130 ft. to be completed when the accident occurred. The foreman in charge of the gang who were working on the removal of the timbers and the concreting, neglected to comply with that part of the instructions relating to the bracing of the timbers above before removing any timbers where the concrete lining was to be applied. In order to hurry the work on faster than heretofore, this part was neglected, and two sets of timbers removed without any bracing of the set above. This caused the sets above to fail, 14 of them altogether falling in, and enough of the rock around the rim of the inclined shaft slipping out of its crevices, when left unsupported by the timbers, to partially fill up the hole and bury the men. One of the men working there realized the danger when he saw the sets were being knocked out without bracing above, and escaped by climbing up before the cave-in occurred. All of the other men except the foreman and a Mexican laborer working with him also realized the danger, so that they had reached points from 20 ft. to 40 ft. above the point where they were working when the cave-in occurred.

There was a bulkhead of 18 × 8-in. timbers over the end of the finished section which prevented any of the material caving in from entering the lined and completed portion of the incline. This bulkhead sustained the weight of the rock falling, and imprisoned the foreman and the Mexican laborer with him in the bottom of the cave. Of the other five men employed, one escaped by climbing, three were killed, one about 20 ft. above the bottom, and the other two 40 ft. above the bottom, and the other, Mr. Lindsey B. Hicks, was caught about 30 ft. above the working point at a place where a skip or car was suspended on the inclined track in the shaft. His life was saved by crouching down near the skip as the collapse of the timbers occurred, the rock falling in such a manner as to imprison him, but leaving sufficient space underneath in which he laid without any pressure against his body.

The cave occurred on Dec. 7, 1906, and work immediately began at the top to remove the caved material and recover the bodies of the entombed miners. It was not known until December 10 that any one was alive, but on that date faint taps on the rail were heard at the upper end of the shaft. These taps were understood by miners, and an answering signal was received whenever the rail was tapped above. From this the conclusion was reached that some one was alive in the midst of the cave-in. The miners' code of signals in use on the work was sufficiently ample to communicate with the imprisoned man to learn that he was at a point in the cave where the skip was located. Then, by measuring the cable on the drum of the hoist, it was determined that this skip was 30 ft. above the bulkhead in the shaft below the cave.

A 1-in. pipe was then started along one of the rails in the incline, and driven down very close to the point where the skip was known to be located. By means of this pipe, it was possible to talk with the imprisoned man, and learn his name and condition, but before the pipe reached near enough to supply him with anything through it, this was twisted off in an attempt to force it down further.

It was then concluded to secure an extra heavy hydraulic pipe having a diameter of about 1 in. and a shell thickness of approximately $^{3}/_{4}$-in. This was quickly secured, tapered slightly at the lower end, and driven down the rail until it reached a point where the imprisoned man could put his mouth to it and obtain nourishment in that manner. As soon as this pipe had been successfully sunk through the space of 35 ft. above the skip, this space being completely filled with fragments of rock and timbers which had fallen in from the sides of the shaft, the imprisoned man was nourished by means of boiled milk supplied him regularly through the pipe.

Conversation was carried on by him, by which his position was definitely learned, and it was concluded that it would be impossible to rescue him by sinking down, owing to the loose and dangerous condition of the material with which the incline was filled.

*Consulting Engineer, Edison Building, Los Angeles, Cal.

A rescue drift was therefore started on the face of the mountain and driven into the place where the miner was imprisoned. This consumed more than two weeks, and resulted in successfully liberating the prisoner on the evening of December 23d, 1906.

In driving the rescue drift the utmost care had to be observed not to cause a cave-in when loose material surrounding the skip was reached. The line and grade of the drift was frequently changed to conform with the formation encountered in the driving, so as not to precipitate a cave-in which would kill the man it was intended to rescue. The condition of this rescue drift is shown in Fig. 3.

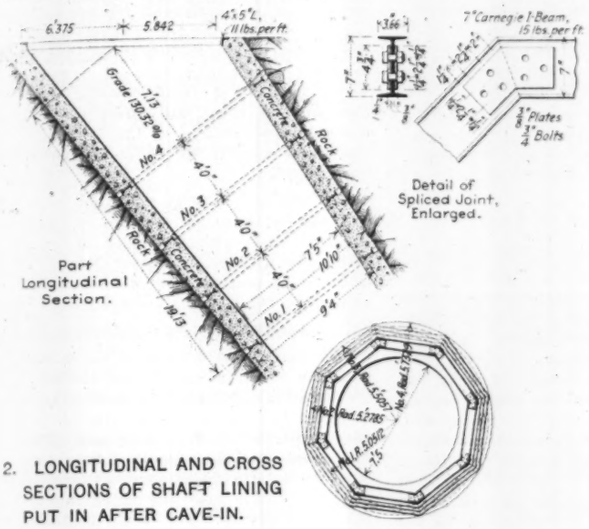


FIG. 2. LONGITUDINAL AND CROSS SECTIONS OF SHAFT LINING PUT IN AFTER CAVE-IN.

In order to insure the successful termination of the attempt at rescue, it was decided to end the drift against the skip in the shaft and on the opposite side from which Mr. Hicks was lying. In this way it was possible to support the formation by using the side of the skip as a bulkhead. The rails underneath were sawed off, a hole was dug and he was extricated underneath the car, without disturbing any of the timbers and rock lying immediately above him.

The difficult part of this work came at the time when the solid ground had been penetrated, and the loose material in the caved shaft was encountered. After this, the most careful studding and bracing of all loose fragments and the loosened rock ahead of the face had to be done in order not to precipitate the movement of the whole mass.

The rescued man was taken out in good condition, having been sufficiently nourished, and soon recovered the use of his limbs and body which had been benumbed by the cramped position in which he lay during his imprisonment. In order to keep up the spirits of the prisoner, music was supplied him by means of a phonograph through the pipe; when he was cold, warm air was sent down; and he was regularly supplied with nourishment. Also when not asleep he conversed with the men employed and officials of the company, in which way he was entertained and kept in a cheerful mood while the rescue drift was being driven.

The Edison Electric Co. defrayed all the expenses of the rescue, the officials of the company taking the position that a human life should be rescued at whatever cost.

To remedy the damage, it was decided to sink through the caved section, and use sets made of 7-in. steel I-beams. These are shown in Fig. 2 for the special taper at the upper end of the shaft, the set at the lower end of this taper being the one used at other points below the taper. The lagging was driven ahead, and these steel sets put in place every 2 ft. through the caved part of the incline, after which the space was filled with fine concrete to the back of the lagging, but no steel lining was placed inside of the concreted tube.

In installing the steel sets, spreaders of iron bars were used to separate them, and hanger rods of ⅝-in. iron, run through the holes in the web of the I-beam, were employed to support them from above, as no wedging from behind was possible.

The placing of the concrete inside was by tamping around the spreaders, hanger rods and sets, thus virtually making a reinforced concrete pipe inside of the shaft. The inside of this was plastered with two coats of cement plaster, one part cement and one part sand, after which it was given two coats of No. 3 P. & B. paint. The concrete employed was of fine texture, and of sufficiently fine material so there would be no percolation of moment through it under extreme pressure at the lower end of the caved section.

Owing to the shaky condition of the surrounding hill overhead, caused by the cave-in, it would have been impossible to restore and finish the shaft as originally planned by means of a steel lining inside and the concrete wedged between it and the bed rock in place. The steel sets, however, reinforce the concrete tube, and make it stronger than necessary to resist the internal pressure of the water in the inclined shaft.

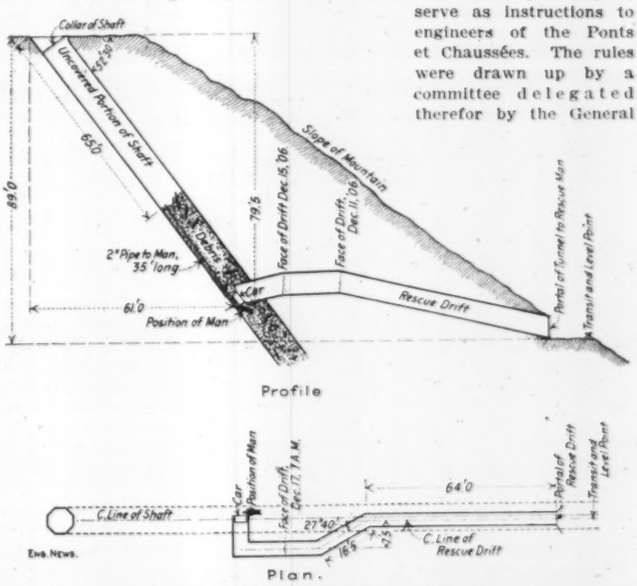


FIG. 3. PLAN AND PROFILE OF DRIFT TO RESCUE MINER ENTOMBED IN CAVE-IN AT POWER PLANT OF EDISON ELECTRIC CO. OF LOS ANGELES, AT BAKERSFIELD, CAL.

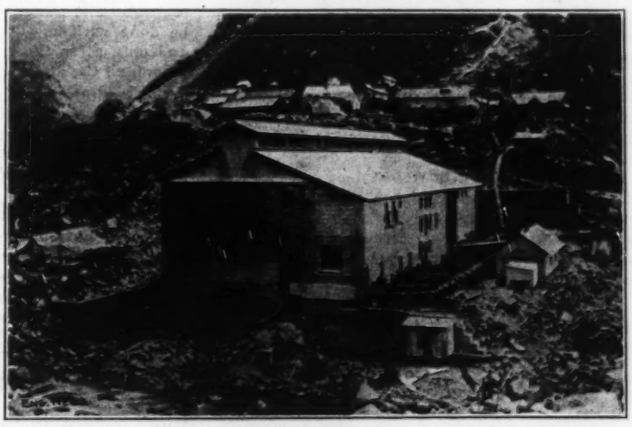


FIG. 4. KERN RIVER POWER-HOUSE OF THE EDISON ELECTRIC CO. OF LOS ANGELES.

The inclined shaft from a cave-in in which a miner was rescued after 14 days' imprisonment, runs from the pipes back of the power-house up to the top of the Mountain, a distance of 1,840 ft., from 100 to 400 ft. below the surface.

FRENCH GOVERNMENT RULES FOR THE DESIGN AND CONSTRUCTION OF REINFORCED CONCRETE.

The French Ministry of Public Works recently had prepared a code of regulations for the design of reinforced-concrete work, primarily to serve as instructions to engineers of the Ponts et Chaussées. The rules were drawn up by a committee delegated therefor by the General Council at the Ponts et Chaussées, and were somewhat modified in final form by the Council itself. This committee recommended that the state of the subject does not warrant the issuance of fixed regulations, and it therefore advised that the rules or specifications which it prepared be termed merely "Instructions." This is in contrast to the specifications for the design of steel bridge and roof work of the department, which are termed regulations.

A brief extract of the principal points of the new instructions should prove serviceable to our readers, especially in view of the fact that there is absolutely no authoritative American code of specifications or practice in existence. In presenting this abstract we follow the text of "Le Genie Civil," "Beton und Eisen," "Concrete and Constructional Engineering," and other foreign sources that have reproduced a part of this matter.

We may note also that the Instructions are subjected to strong criticism in some points by Prof. F. Schüle of Zürich in the "Schweizerische Bauzeitung" of Jan. 19, 1907. Prof. Schüle characterizes the directions for calculating deformations as not in agreement with test results, and criticizes the allowed stresses as exceeding the limits recognized by the German and Swiss prescriptions, which, he implies, give a margin of safety none too high. He rightly remarks, in reference to the many recent failures of reinforced concrete (in Europe as well as America), that whether faulty execution or other errors be responsible, it is obvious that more accidents must occur if the margin of safety is decreased.

LOADS.

Bridges and roof structures in reinforced concrete are to be calculated for the same loads as specified in 1891 and 1903 for metal bridges and railway station roofs. Where these loads do not apply, structures are to be calculated for the greatest load which they will be called upon to carry in service.

STRESSES.

COMPRESSION IN CONCRETE.—The compressive stress in reinforced concrete shall not exceed 0.28 of the crushing strength of plain concrete of the same composition at the age of

90 days (tested in 8-in. cubes). Higher stresses are permissible only when the concrete is hooped (fretté) or has transverse reinforcing adapted to resist the swelling of the concrete under the influence of longitudinal compression. But in any case the maximum stress shall never exceed 0.60 of the crushing strength above defined. The relation between the stress and the transverse reinforcing is indicated by the formula

$$0.28\ (1 + m'\frac{V'}{V})$$

in which V′ is the volume of the transverse or oblique reinforcing, V is the volume of concrete in the same length of the member, and m′ is a coefficient depending on the nature of the transverse reinforcement as follows:

(a) Transverse Ties.—With transverse ties forming rectangles in the cross-section of the member, m′ may lie between 8 and 15: the minimum 8 in the case where the spacing of the ties is about equal to the least transverse dimension of the member, and the maximum 15 when the spacing of the ties is as small as ⅛ of the least dimension of the member.

(b) Hoops.—In members hooped spirally, m′ may lie between 15 and 32: the minimum when the coils are spaced as much as 2-5 of the least dimension of the member apart; the maximum 32 when the coils are spaced a distance apart not more than 1-5 the least transverse dimension of the member in the case of a compressive stress not over 700 lbs. per sq. in., or ⅛ the least dimension for a stress of 1,400 lbs. per sq. in.

SHEAR AND BOND.—The maximum stress in shear and bond shall not exceed 1-10 that allowed for compression.

STRESS IN STEEL.—The maximum stress in tension as well as in compression for the reinforcing metal shall be not over ½ of its apparent elastic limit, except that in members which resist shock or alternating stresses the steel shall not be stressed to more than 0.40 of its apparent elastic limit.

REDUCTION OF ALL STRESSES.—All the stresses above defined shall be reduced in case of very variable loading, the maximum reduction being 25%. Reduction shall also be made in the case of dynamic actions which cannot be definitely estimated, as in the case of track stringers in railway bridges.

STRESS COMPUTATION.

All calculations of stresses in reinforced-concrete structures shall not only take account of the greatest external forces, including the action of snow and wind, but must also consider expansion and contraction due to temperature changes and the shrinkage of the concrete, except in case of structures in which free expansion is possible.

Rational methods shall be employed for all calculations, and not empirical procedure.

For example, the following method may be used:

$$\text{Effective section } A = A_b + mA_s$$

where A_b and A_s are the cross-sections of concrete and reinforcement and m is a coefficient which may be taken between 8 and 15. The minimum value of m applies when the longitudinal reinforcement has a diameter as great as 1-10 the least dimension of the member, or has cross-ties whose spacing is as much as the least dimension of the member, or terminates near the free surface of the concrete; the maximum value of 15 applies when the longitudinal reinforcement has a diameter as small as 1-20 the least dimension of the member, or cross-ties spaced not over ⅓ the least dimension of the member. Further, using these values, the center of gravity or position of the neutral axis of the member is to be found by the formula

$$Ay = A_b y_b + mA_s y_s$$

in which y, y_b and y_s are the distances of the centers of gravity of the effective section, the concrete and the reinforcement, respectively, from any selected axis perpendicular to the axis of symmetry of the member. The effective moment of inertia is

$$I = I_b + mI_s$$

Generally these three formulas may be expressed in other form by using the total cross-section in place of the cross-section of concrete; thus,

$$A = A_t + (m - 1)\ A_s$$
$$Ay = A_t y_t + (m - 1)\ A_s y_s$$
$$I = I_t + A_t\ (y - y_t)^2 + (m - 1)\ I_s$$

in which A_t, y_t and I_t refer to the total section. Then if N is the total normal compression, the unit stresses S_b and S_s are

$$S_b = \frac{N}{A}$$
$$S_s = m\frac{N}{A}$$

In compression combined with bending, the direct compression being N and the bending moment M, the maximum and the minimum stresses are

$$S_b = \frac{N}{A} + \frac{M}{I}c_b$$
$$S'_b = \frac{N}{A} - \frac{M}{I}c'_b$$
$$S_s = m\left(\frac{N}{A} + \frac{M}{I}c_s\right)$$
$$S'_s = m\left(\frac{N}{A} - \frac{M}{I}c'_s\right)$$

These formulas, of course, apply only in case the stress is compressive over the full section; otherwise they undergo modifications.

In all calculations for stresses, concrete shall be considered to have no tensional resistance, but in calculating deformations the tensile resistance of the concrete is to be taken into account. [The values of A and I above given can therefore be used directly in computing deflections; but in calculating bending stresses the method in general use in American practice will apply, except that the ratio m, corresponding to the usual $n = E_s/E_c$, is specifically defined. Several special notes on the calculation of rather common instances of indefinite loading or doubtful analysis are given as follows:]

Top Flange T-beam.—In calculating beam and slab floors, the width of slab which may be counted as compression flange of the beam, thereby forming a T-beam, is a width b defined as follows: If e is the thickness of the slab, d the spacing of the ribs, and l the span of the beams, then b shall not exceed ¾ d and shall not exceed ⅓ l.

2. Concentrated Loads.—Concentrated loads between ribs of a floor may be considered distributed over a rectangle of which the concentrated load is the center, whose sides perpendicular to the ribs shall be e plus depth of filling and floor surface, and whose sides parallel to the ribs shall have a length equal to this quantity plus ⅓ d. The slabs shall be provided with reinforcement in both directions, and the reinforcement parallel to the ribs should have a cross-section per unit width not less than half the section of transverse reinforcement per unit width. The slab shall be calculated as having a span length equal to d, the center-to-center distance of ribs.

3. Crossed Ribs.—If a ribbed floor has two sets of ribs at right angles to each other, with spacing d and d′ respectively, the slab may be calculated by the following formula: The bending moment on the span d may be reduced by the coefficient

$$\frac{1}{1 + 2\left(\frac{d}{d'}\right)^4}$$

and similarly for the other direction of bending d′.

BOND STRESS.—The bond stress between the concrete and the tensile reinforcement should be investigated. If a is the section of one reinforcing rod, p its perimeter, S and S′ the unit tensile stresses on two transverse sections separated by the small distance z, then the bond stress $\frac{a\,(S - S')}{pz}$ shall not exceed ⅒ the maximum allowed compressive stress in the concrete. But if the stirrups or other transverse reinforcement are solidly connected with the longitudinal reinforcement, this may be changed to read that $\frac{a\,(S - S') - F}{pz}$ shall be less than ⅒ the allowed compression in concrete representing the shearing resistance of the stirrups. Simple ties, however, shall not be considered to come under this last rule.

SHEAR.—The longitudinal shear at the neutral axis should be investigated. The sum of $A_s\,(S_s - S'_s)$ should be less than ⅒ the allowed compression in concrete; a_b in this formula is the area of the horizontal transverse section of the concrete near the neutral axis on the $\frac{a_b z}{}$. If the preceding condition is satisfied, the vertical shear will be taken care of. In case of transverse or inclined reinforcement, the shearing resistance of these will affect the longitudinal shear in the concrete at the neutral surface in the same manner as above explained for the bond stress.

COLUMNS.—Columns need not be calculated for buckling when the quotient of length divided by least transverse dimension is less than 20. When this quotient is greater than 20, a formula of the Rankine type, with B equal to 10,000, shall be used to reduce the allowable compression.

CONSTRUCTION AND TESTING.

The quality and mixture of the materials is to be given in all proposals and the like for concrete work. Sufficient water must always be used to make the concrete so plastic as to surround the reinforcement thoroughly and fill all voids. The forms, and the support of the reinforcement, must be so stiff as to resist without perceptible deformation the load and shock imposed during the construction. The concrete must be deposited with care in layers not exceeding 2 ins., except in case large stone are used in the concrete and except in case the concrete work is poured. The spacing of the reinforcement and the distance between the forms and the reinforcement must be such as to permit of thorough tamping and complete filling of voids, and shall be at least ⅝ to ¾-in.

The concreting of a member should be continuous, but if interruption is unavoidable, on resuming work the surface of the old work shall be cleaned down to sound concrete and thoroughly wet before fresh concrete is deposited. Concrete work shall be stopped in freezing weather, and when work is resumed all concrete which appears to have been frozen shall be removed.

Concrete work shall be kept as moist as necessary to ensure set, during at least 15 days after placing. The removal of forms and centers shall be done without shock, by purely static forces, and only after the concrete is strong enough to withstand the stresses to which it will be exposed.

The testing of bridges and roofs before acceptance is governed by the rules of the earlier Regulations of 1891 and 1903, referring to steel structures. Floors shall be tested by a load at least as great as the designed load, on an area at least equal to one panel. Such loads shall remain in place at least 24 hours, and the deflection shall not increase after the first 12 hours. The age of the concrete work at the time of testing shall never be less than 30 days (floors), shall be at least 45 days for structures of moderate importance, and at least 90 days for large structures.

USE OF A TRACTION ENGINE IN RAZING RUINS AT SAN FRANCISCO.

The greater percentage of the amount of work now going on in the razing of the ruins at San Francisco is being carried on by means of the ordinary hoisting engine equipped with tackle and cables. In the very heavy work, particularly among the steel-frame and concrete structures, this method does not suffice and to replace it a large traction engine has been put into use.

This machine was built by the Holt Manufacturing Co., of Stockton, Cal. Its total weight with coal and water tanks full is nearly 25 tons and the engine has 75 I. HP. The two propelling wheels are each 6 ft. in diameter with tires 18 ins. wide. The machine has recently been used to pull down the walls of the old City Hall.

A CENSUS OF HIGHWAY TRAFFIC IN ILLINOIS.

In considering country highway improvements an important matter which is almost entirely neglected is the actual amount of traffic carried by individual roads. Where a road is said to have light or heavy traffic, it is an estimated comparison with some other road, and conveys no definite idea as to the actual number of vehicles or their character. In some rare cases estimates are made, but these are almost entirely guesswork, and there is practically no definite or reliable comparative statistical information as to traffic conditions on country roads. An important step towards obtaining definite information on this point has been undertaken in Illinois under the direction of Mr. A. N. Johnson, Assoc. M. Am. Soc. C. E., State Highway Engineer, who described the progress and results of the work in a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors at Peoria, Ill., in January, 1907. An abstract of this report is given below, with examples of some of the diagrams prepared from the census sheets, for which diagrams we are indebted to Mr. Johnson. A review of the organization and work of the State Highway Commission of Illinois, under the law passed in 1905, was given in our issue of June 14, 1906.

Our abstract of Mr. Johnson's paper is as follows:

It was determined to make an actual count of the vehicles on a number of roads in different parts of the state in order to obtain information as to the following points: (1) The difference in the traffic over roads leading into large towns and those leading into smaller towns; (2) the effect which the condition of the roads has upon travel; (3) the effect due to the industries in a particular neighborhood. No attempt has been made to sum the total traffic on all the roads, as this would be a practical impossibility and for the present purposes not at all necessary. On a number of roads two stations have been established; one near the city or town to which the traffic comes, and another three or four miles out. Between these stations are usually found two or three cross roads which must supply the difference in the amount of traffic noted at the two stations. At present there are 37 of these stations or points of observation. The method of counting and classifying traffic is to give separately the vehicles going toward the city or town, and those going away from the town; distinction is also made between loaded and unloaded vehicles. The number of horses or animals attached to each vehicle is recorded and the record for each hour kept separate. The conditions of the weather and the road are also included.

Each traffic station was established at some house near enough to the town to include all the traffic going to and coming from the country, but far enough out to exclude merely street traffic. The blanks were purposely made as simple as possible, with the idea that they could be kept by any bright boy or girl. The count was made at all stations on the same day, and about four times a month. The days were so selected as to cover, for instance, Monday of one week, Tuesday of the next, Wednesday of the next, and so on. In this way it would be possible to show what variation, if any, the day of the week made. In winter the traffic was recorded during the daylight hours; at other seasons of the year from 6 a. m. to 7 p. m. The observers were paid $1 for each day the count was kept. This general method of taking the traffic census has proved satisfactory in every instance. Only a few of the stations show winter traffic, as the majority were not established until the spring or early summer. It is proposed, however, to continue the observation at each station for at least a full year, as the importance of the date already collected fully warrants a continuation of this work.

Five stations were established in the vicinity of Springfield;* two on the main road south and two on the main road east (along each of which run interurban lines), and the fifth station on a road northwest of the city. Double stations were also established on roads leading into Peoria and Rockford.* The most striking feature found in these reports is brought out graphically in the diagrams, Figs. 1, 2 and 3, which indicate very clearly the variation in the traffic on the roads into different towns. The height of the heavy lines represents the relative amount of traffic in each instance. It will be noticed in Fig. 1 that during March and the first part of April, when the roads are extremely bad, the traffic into Springfield (which is over earth roads) is very light; whereas the traffic during good weather is many times greater. The traffic into Rockford, Fig. 2, shows an increase in good weather, but the amount in bad weather is in very much greater proportion than on the earth roads.

*Population, 1900: Springfield, 34,160; Peoria, 56100; Rockford, 31,050; Elgin, 22,430; Elburn, 600; Greenville, 2,500.

This traffic comes in over a macadam road. The traffic into Peoria, Elgin (Fig. 3) and Elburn* is remarkably uniform throughout the year; the roads in the vicinity of all these stations are gravel. In the vicinity of Elgin and Elburn, dairy farming is carried on extensively, which necessitates daily marketing of products. The greatest influence on the traffic is the weather and the resulting conditions of the roads.

Another striking fact is that the size of the town to which the traffic comes is by no means a measure of the amount of traffic over the road. Where there are two stations the amount of traffic at the farther station, which is but two or three miles beyond the station nearest town, has very much less traffic; that is, the amount of traffic recorded on these roads extends for a comparatively short distance, so that the travel on the road two or three miles out is but one-fourth the amount on the portion of the road nearer town. It is, therefore, evident that if the amount of money to be spent on a particular road is to be in proportion to its use, the first

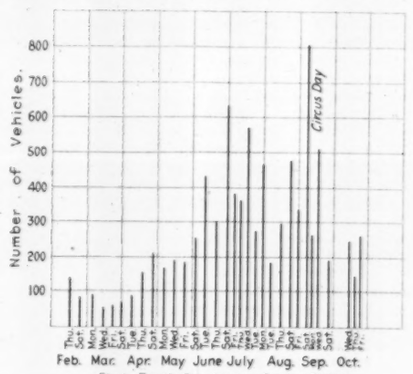


Fig.1. Earth Road near Springfield.

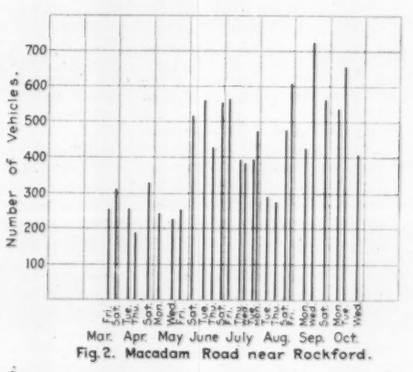


Fig.2. Macadam Road near Rockford.

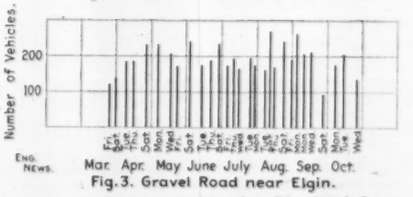


Fig.3. Gravel Road near Elgin.

Figs. 1 to 3. Diagrams Showing Result of Census of Country Highway Traffic in Illinois.

two or three miles near town should have four or five times as much spent on them as on more distant sections.

Additional records have been made on special occasions, such as when a circus was in town. The figures thus obtained show the maximum use that is made of a particular road, and the maximum amount of traffic. Thus we find on the road into Greenville a total of 1,283 vehicles on July 12, while the average number at that time of the year is but 340 per day. There is also found to be a great variation in the hour of the day when the maximum traffic occurs. Thus the traffic into Elgin is fairly well distributed throughout the middle part of the day, while the traffic at Peoria occurs between 7 and 9 a. m. coming in, and 2 to 4 p. m. going out. The most marked hourly variation in traffic occurs on the road to Elburn. At this point each report shows a large amount of inward traffic between 8 and 9 a. m., and outward between 10 and 11 a. m. These are instances where it is necessary for the business of a community to use the road not only every day in the year, but at a certain hour of the day.

The greatest variation in the use of the roads seems to be where there are nothing but earth roads, which necessarily become extremely bad in winter and spring. It is a practical impossibility in the vicinity of Springfield, for instance, to engage in business pursuits which require the daily use of the roads such as is made of them about Elburn, Elgin and Rockford. The condition of the roads about the latter places is such that business can be done daily with certainty. It may be said, and possibly it is true, that the business about Springfield and other points does not require the daily use of the roads, but it is also true that these communities could not engage in any pursuits that would require such a use of the roads in their present condition.

While conclusive deductions should not be drawn without additional records, it seems that the evidence furnished warrants some general observations. A country road is well traveled that has a daily average in fair weather of 300 vehicles or over; 600 vehicles a day is an exceptionally large traffic, and over 1,000 vehicles of very rare occurrence. The majority of the vehicles are reported drawn by two horses, seldom by more than two.

SOME TESTS IN SIGHTING AT LEVELING RODS AND STADIA RODS.*

By JOHN C. TRACY.†

This paper gives the results of four sets of tests made to determine the probable errors in the following operations:

(1) Setting a target on a leveling rod.
(2) Reading a rod directly without using a target.
(3) Measuring horizontal distances with the stadia.
(4) Measuring differences in elevation by the stadia and vertical-angle method.

The object in each case was to determine the maximum error likely to occur in ordinary practice, rather than to ascertain the highest degree of precision which might be attained in special cases. For this reason conditions for the tests were chosen which were more unfavorable than those that prevail in ordinary practice. Not only were many of the instruments and rods in poor condition, but the work was assigned to students just beginning the subject of surveying, and who were, therefore, much less skilful than the average surveyor.

With more than 125 students in the field at one time, an excellent opportunity was afforded to obtain a large number of observations from which to calculate the probable errors by the theory of least squares. Some of the results given are based upon as many as 1,200 independent measurements. The probable error of a single observation determined from a large number of observations, indicates the precision which may be expected in any single observation made under the same conditions.

PROBABLE ERROR OF SETTING A LEVEL TARGET.

CONDITIONS.—Three levels were used. Levels No. 1 and No. 2 were 18-in. wye-levels, 1⅝-in. objective, and magnifying power of about 35 diameters. Level No. 3 was a 15-in. wye-level, 1⅛-in. object glass, and magnifying power of about 30 diameters. Each of the three level rods had a vernier scale on the target. The sun was shining and the air was "boiling" slightly.

METHOD OF PROCEDURE.—At each level was a party of 18 students, each of whom had used the level just long enough to become accustomed to sighting. The rod rested on a solid support 100 ft. from the level, care being taken to hold it plumb while each student in turn set the target. In order that there should be as little disturbance of the level as possible it was set up with two leveling-screws in the line of sight, an umbrella was held over the instrument, and an instructor kept the bubble in the center of its tube. In this way the discrepancies between the target settings by different students were due almost wholly to errors in sighting. To eliminate as far as possible errors in reading, an instructor read the rod for all settings. The tests were repeated with the rod at 200 ft. and 300 ft. from the level. Each of the quantities in the following table is the probable error of a single observation calculated from eighteen observations.

TABLE I.

Instrument.	Length of sights, in ft. 100	200	300
Level No. 1.....	0.00196	0.00196	0.00370
Level No. 2.....	0.00147	0.00229	0.00327
Level No. 3.....	0.00130	0.00157	0.00213

CONCLUSIONS.—The results, as obtained from 54 observations at each distance, indicate that for beginners, at least, the chances are even that the error of sighting and of setting the target will not exceed, say 0.002-ft. for a 100-ft. sight, 0.0023-ft. for a 200-ft. sight and 0.0037-ft. for a 300-ft. sight. With better instruments and more experienced observers very likely the errors would be less, but probably the results are not far from those obtained in ordinary practice. Incidentally, the effect of the sun shining on the instrument was made very apparent by taking readings after the umbrella had been removed.

PROBABLE ERRORS OR READINGS MADE WITHOUT A TARGET.

CONDITIONS.—Readings were taken by more than one hundred students working in pairs, but, unfortu-

*Paper presented at 23d Annual Meeting of Connecticut Society of Engineers, Hartford, Feb. 12-13, 1907.

†Assistant Professor, Structural Engineering, Yale University.

nately, no precautions were taken to protect the instruments. A larger number of levels were used, some of which were decidedly inferior to those described above; and the "speaking" rods were of various styles, with graduations more or less dim from constant wear. Each quantity in the table is the probable error of a single observation as computed from more than 100 observations at each distance.

TABLE II.

Length of sight, in ft.....	50	100	150	200	250	300
Probable error..	0.0024	0.0035	0.0038	0.0048	0.0062	0.0065

CONCLUSIONS.—In the preceding test the discrepancies in setting the target were due almost wholly to errors in sighting, but in this test, since no precautions were taken to shade the level or to keep the bubble in the center, the errors were due in part to changes in the instruments. Hence the target readings and the direct readings cannot be compared, except that it is evident that the target readings are but slightly more accurate than direct readings, even though taken under much more favorable conditions. The speed gained in the use of a self-reading rod is obvious, and these results confirm the belief that the target is an encumbrance, rather than a help, in a large part of ordinary leveling. As a matter of fact, a self-reading rod is generally used in precise leveling, where a result reduced from the readings obtained from three horizontal cross-hairs is probably more accurate than a single observation upon an ordinary target.

In ordinary leveling the errors made in estimating fractional parts when a self-reading rod is used are compensating, so that in running a line of levels the results would be even more accurate than the table would indicate.

PROBABLE ERRORS OF HORIZONTAL MEASUREMENTS MADE WITH THE STADIA.

CONDITIONS.—Five transits were used of several different makes; magnifying power of telescopes from 20 to 24 diameters; adjustable stadia wires; constant corrections about 1.1 ft. Stadia rods K. and E., No. 6284.

METHODS OF PROCEDURE.—Five stakes for each transit were driven, approximately in line, on level ground and at distances of about 100 ft. apart. These distances were not measured with a tape until after all the stadia readings had been taken. Each transit was set up over the first stake in its row and approximately 50 students read the stadia distance from each transit to each of the four stakes in the corresponding row. The distances to the first stakes varied from 90 to 125 ft.; to the second stakes from 185 to 210 ft., and so on up to a little more than 400 ft. for the last stake in each row. With ordinary instruments the accuracy of the stadia reading decreases rapidly for distances greater than 400 ft., and hence tests were not carried beyond that point. None of the students who took the readings had had experience in the use of the stadia, in fact most of them had never sighted at a stadia rod until a few minutes before the tests were begun. The results indicated that in a number of cases the student forgot to add the constant correction of one foot, but such results were allowed to stand and only an occasional blunder of an even 10 ft. was thrown out. Each of the quantities in the following table is a probable error of a single observation as found by least square from approximately forty to fifty readings by different students. Thus the table represents about 1,000 different readings.

TABLE III.—Probable Errors of a Single Observation.

Distances, in ft.....		90-125	185-210	285-300	415-435
Transit No.	1.....	0.28	0.46	0.94	1.07
" "	1.....	0.51	0.74	0.77	0.96
" "	2.....	0.55	1.19	0.95	0.83
" "	2.....	0.76	0.87	0.90	1.22
" "	3.....	0.40	0.63	0.71	0.79
" "	3.....	0.25	0.46	0.55	0.78
" "	4.....	0.39	0.90	0.64	0.96
" "	4.....	0.92	0.32	1.18	0.62
" "	5.....	0.69	0.58	0.82	0.97
" "	5.....	0.51	1.07	0.84	1.08
Mean		0.51	0.72	0.83	0.93
Minimum		0.25	0.32	0.55	0.62
Maximum		0.92	1.19	1.18	1.22

CONCLUSIONS.—The results show that, so far as sighting is concerned, the chances are even that the maximum error which will occur in reading distances by the stadia method will not greatly exceed 1 ft. up to distances of 400 ft. The mean of the probable errors 0.5, 0.7, 0.8 and 0.9-ft. for 100, 200, 300 and 400 ft., respectively, represent more nearly what may be expected in practice. These results do not indicate, however, the discrepancies to be expected between tape measurements and stadia measurements, since such discrepancies will involve constant errors, which are not involved in the mere act of reading the rod, such, for example, as errors in the wire interval and errors in rod graduations. In order, therefore, to determine what the discrepancies really were, each of the distances was measured with a tape. Each quantity in the following table is the mean of approximately 50 discrepancies, i. e., the readings of approximately 50 students at each transit and for each distance were compared with the tape measurement for that distance and the mean of the 50 discrepancies entered in the table.

TABLE IV.—Mean Discrepancies Between Stadia and Tape Measurements.

Distance, in ft.....		90-125	185-210	285-300	415-435
Transit No.	1.....	0.58	0.66	1.37	1.77
" "	2.....	0.65	1.30	1.09	1.30
" "	3.....	0.57	0.65	0.73	1.87
" "	4.....	0.44	0.63	0.93	0.99
" "	5.....	0.70	1.50	1.60	2.40
Mean		0.59	0.95	1.14	1.66
Minimum		0.44	0.63	0.73	0.99
Maximum		0.70	1.50	1.60	2.40

It is evident from the table that transit No. 5 gave much poorer results than the other transits. This inferiority is not so evident in Table III. and is therefore probable due in large measure to poor adjustment of the stadia wires. Allowing the results to stand as they are, it would appear that the average discrepancy between horizontal measurements as found with the stadia and with the tape are about 0.6, 0.9, 1.1 and 1.7 ft. for 100, 200, 300 and 400 ft., respectively. Of the five transits No. 5 was by far the poorest. It had been in use more than twenty years, and though the stadia wires were adjusted before the tests were made, it is probable that the wire interval was incorrectly taken. The maximum discrepancies as indicated in the lower row are, therefore, larger than those which would occur in ordinary practice. It should be kept in mind also that all the quantities in the table represent results obtained under most unfavorable conditions.

PROBABLE ERRORS OF VERTICAL MEASUREMENTS MADE WITH THE STADIA.

From Table III. 0.5, 0.7, 0.8 and 0.9 are the mean of the probable errors in sighting at distances of 100, 200, 300 and 400 ft., respectively. Taking these quantities as a basis and assuming that the error in the vertical angle will not exceed a minute, the error in differences of elevation may be computed from the usual stadia reduction formula. In the same way, taking the maximum values from Table III. as 0.9, 1.2, 1.2 and 1.2, respectively, the maximum probable errors may be computed in the same way. These values are given in Table V. for angles of 3°, 5°, 10°, 15° and 25°, the latter angle being as large as is likely to occur in practice.

The above table is based on the error of sighting only. The mean values in Table IV., however, are less than the maximum values in Table III., except for 400 ft., so that the results in Table V. indicate approximately what may be expected in ordinary practice, provided the error in the vertical angle does not exceed one minute. Thus for example, the error in elevation should ordinarily not exceed 0.4 ft. for angles up to 15° and sights up to 400 ft. If, however, the transit is as unreliable as No. 5, which gave an error of 2.4 ft. in a horizontal distance of 400 ft. (see Table IV.), the resulting error for one minute error in a 15° vertical angle would be about 0.7 ft. for a 400-ft. sight. The error in the vertical angle is affected not only by the reading of the vertical arc, but also by the adjustments of the level tube and the sensitiveness of the bubble. Hence, it may easily exceed one minute. If, however, it is as large as 5 minutes, the error in elevation as obtained by Transit No. 5 would not exceed 1.1 ft. in a 400-ft. sight.

As a test of the actual discrepancies due to all sources of error five transits were set up and the elevation obtained by stadia and vertical angle of three points at distances of about 100, 200 and 150 ft., respectively, and at vertical angles of about 5°, 10° and 15°, respectively. Independent readings were taken by from 20 to 30 students at each transit, and the maximum discrepancy between the elevation of each point as found by the stadia and as found by spirit leveling is shown in the following table:

TABLE VI.—Maximum Discrepancies Between Elevations Found by the Stadia Method and Elevations Found by Spirit Leveling.

	Angle=5°. Distance=100 ft.	Angle=10°. Distance=200 ft.	Angle=15°. Distance=150 ft.
Transit No. 1..	0.48	0.81	0.77
" " 2..	0.29	0.69	0.49
" " 3..	0.23	0.73	0.73
" " 4..	0.39	0.32	0.86
" " 5..	0.32	0.85	1.13
Mean of maximum	0.34	0.68	0.80

The inferiority of transit No. 5 is again apparent. Since each value given is a *maximum* discrepancy, all the values are greatly in excess of the *average* discrepancies likely to occur in practice. As a matter of fact the greater number of discrepancies were more nearly like those in Table V., and in many cases were no less. The values in Table VI., however, showing the stadia method in the worst possible light, indicate the use of the method, especially for such work as taking contour elevations in topographic surveying, where, of course, it is most used.

The object of the tests described in this paper was to determine the maximum errors of single observations under unfavorable conditions. When a number of observations are combined as, for example, in running from station to station, errors are largely compensating and the total error is correspondingly small. Many examples of extremely accurate work in stadia surveying have been recorded. Thus, for instance, in Engineering News, June 28, 1900, very complete comparisons of stadia and tape measurements are given where the degree of precision varies from 1 : 1660 to 1 : 2500. Discrepancies in elevations between stadia and spirit leveling, taken at random from the many results given, are 0.01 ft. for a line 2,000 ft. long, and 0.49 ft. for a line 2,500 ft. long. It is to be noted, however, that in this survey (Oswego Mohawk Ship Canal Route) the ground cover was favorable for leveling operations.

Professor Smith of the University of Wisconsin in a series of tests to determine the effect of "differential refraction" (see Engineering News, June 6, 1895), secured some interesting results which indicate how the degree of precision can be greatly increased in stadia surveying by taking certain precautions in determining the stadia interval. The stadia tests described in this paper were made in order to determine what degree of precision may be expected at the other extreme, when no unusual precautions are taken, when the instruments are not of the best, and when the observers are not expert in the use of the stadia method.

TABLE V.—Errors in Elevation for an Error of One Minute, Based on the Probable Errors in Table III.

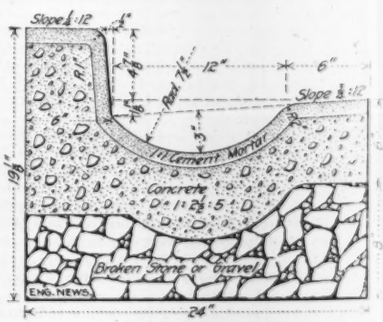
Vertical angle. Distances in ft.	3° Max.	3° Min.	5° Max.	5° Min.	10° Max.	10° Min.	15° Max.	15° Min.	25° Max.	25° Min.
100	0.07	0.05	0.11	0.07	0.18	0.12	0.25	0.15	0.36	0.21
200	0.11	0.09	0.16	0.12	0.27	0.18	0.35	0.23	0.50	0.31
300	0.14	0.12	0.19	0.16	0.30	0.23	0.38	0.28	0.52	0.37
400	0.16	0.15	0.22	0.20	0.33	0.27	0.40	0.33	0.54	0.42

CONCRETE GUTTER AND CURB FOR THE JAMESTOWN BOULEVARD, VIRGINIA.

By V. W. DOW.*

As an engineer engaged in highway construction, I have been much impressed by the lack of good engineering and of common sense in the management of the surface drainage of roads, streets and sidewalks, that I see all over the country. It seems as though a proper study of the problem was not made but that old precedents were blindly followed without considering the fact that the economic relation of structural materials has changed greatly in the past few years, such as the relative cost of concrete and stone masonry or brick. It is in the construction of curbs and gutters that this fact of the generally poor practice above referred to is the most obvious.

The usual gutter is practically a continuation of the street crown curve in the form of bricks, stone block, slabs or cobbles, and in some cases



Concrete Gutter and Curb for the Jamestown Boulevard.

the pavement itself is carried to the curb. Now, in my definition of the word, this is no gutter at all. The water runs in the angle between the curb and the street crown curve and in a violent rain the water backs up onto the pavement, washing macadam, rotting asphalt and producing a generally muddy condition on any kind of pavement. Pedestrians often have to wade in deep puddles in crossing the streets before they can reach the sidewalks. The destructive effect on macadam is especially great. Often the stone washes so badly at the edge of the gutter that

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the water finds its channel there and finishes the work of destruction.

The writer has recently been obliged to design a gutter for a portion of the Jamestown Boulevard, now being constructed between Norfolk and the Jamestown Exposition Grounds. The accompanying blue print is the result. The most obvious thing about it is the curved waterway in the form of a segment of a circle with its chord inclined at the same slope as the last quarter of the street and the first 6 ins. of the gutter. This slope is ¾-in. to 1 ft. This plane lip practically continues the roadway and makes it possible to secure a smooth joint with the pavement and thus allows the water to run freely into the gutter, which is the main feature of the design. This segment has about a 12-in. chord and a 3-in. rise, making its area 25.2 sq. ins., or about that of a 6-in. pipe (28.2 sq. ins.). It is obvious that there is a chance for a large amount of water to run before the triangular space between the chord and the level line from the edge of the gutter is filled. This latter space represents the ordinary gutter of one plane. The volume of concrete has not been increased above that in an ordinary concrete gutter, though the mortar surface has been and the construction is not difficult with the proper templates of sheet iron.

The advantages of a combined concrete curb and gutter of this type in the way of looks, efficiency and cost is so great that it seems the obvious thing wherever a good concrete stone is available at a reasonable price. In the present case the soil is sandy and well drained. On a heavy clay it would be well to add a 3-in. drain tile in the broken stone foundation and to increase the depth of the foundation to 12 ins.

SKEW BRIDGE OF REINFORCED CONCRETE: WABASH RY.

An interesting example of reinforced-concrete bridge construction is a skew bridge now being built to carry the Wabash Ry. over the Sangamon River near Decatur, Ill., in which the four arches have a clear span of 58 ft. 3½ ins. measured on the square, while the piers are 100 ft. c. to c., measured on the center line of the bridge. The rise of the arch is 30 ft. At each end are long hollow abutments, having straight and vertical walls, connected by cross walls or diaphragms and carrying a slab floor, while low retaining walls for shore protection extend from the abutments along the river bank. The bridge was designed by Mr. A. O. Cunningham, M. Am. Soc. C. E., Chief Engineer of the Wabash Ry., to whom we are indebted for plans and other information. The contractors are Wm. P. Carmichael & Co., of Williamsport, Ind. Work was commenced in July, 1906, and will be completed by about June, 1907. The bridge will cost about $117,000. It will take the place of an iron deck structure built in 1885, consisting of one 108-ft. truss span, two 116-ft. truss spans, and two 40-ft. plate-girder spans.

The general features of the structure are shown in the plan and elevation, Fig. 1, while Fig. 2 shows the details of one of the large arches. The piers are founded upon piles driven in a bed of gravel, and have flat foundation footings reinforced with steel rods. The arches have longitudinal reinforcing bars near the extrados and intrados, and transverse bars across these, as shown in Fig. 2. The spandrel walls also have horizontal reinforcing bars. All steel reinforcement consists of the Johnson corrugated bars. The concrete is made with gravel, and its composition is as follows: For arches, slabs carrying tracks, and footings for piers, 1:2½:5. For piers, spandrels, abutments and lower slabs, 1:3:6. The concrete in each arch ring will be deposited without interruption until completion, the work being carried on night and day. There are no parapet walls, the tops of the ties being level with the top of the spandrel walls, but presumably guard rails will be laid across the structure to ensure safety in case of any derailment, as the Wabash Ry. uses inside guard rails and outside guard timbers on its steel bridges.

The assumed live load on the structure is 9,000 lbs. per lin. ft. for each track. The allowed working stresses are 600 lbs. per sq. in. for compression in concrete and 12,000 lbs. per sq. in. for tension in steel.

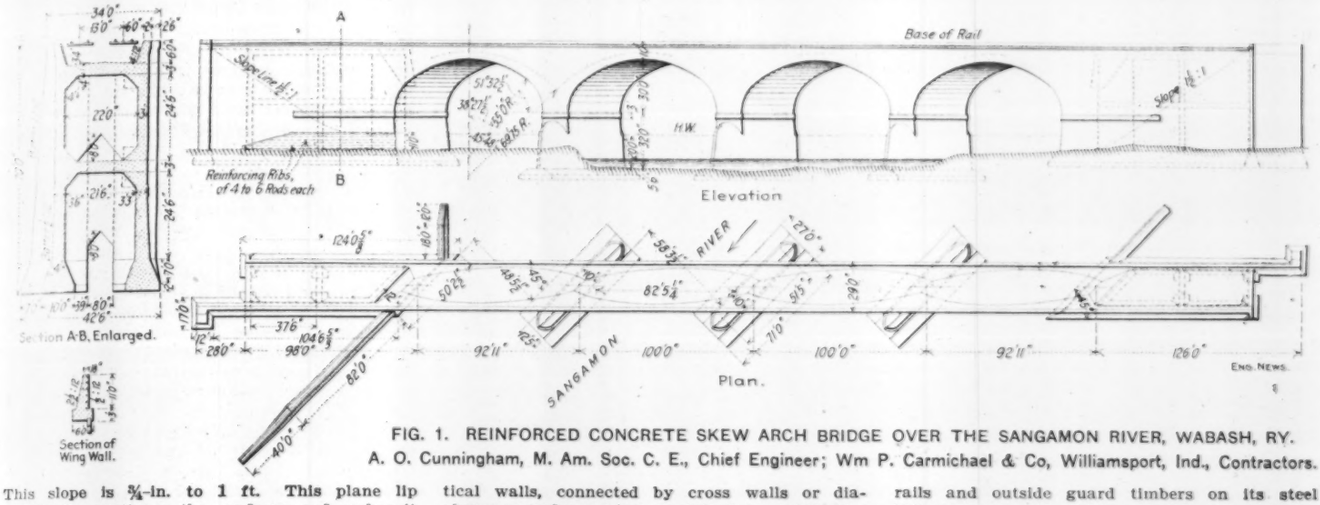

FIG. 1. REINFORCED CONCRETE SKEW ARCH BRIDGE OVER THE SANGAMON RIVER, WABASH, RY.
A. O. Cunningham, M. Am. Soc. C. E., Chief Engineer; Wm P. Carmichael & Co, Williamsport, Ind., Contractors.

THE PENNSYLVANIA RAILROAD IMPROVEMENTS at Wilmington have just been put in commission. This work consists of a viaduct three miles long carrying the tracks of the main line through Wilmington on a series of bridge arches and 24 plate-girders over the streets. In an effort to make the roadway as noiseless as possible, special care has been made in the design. The floors of the bridges are of steel, and of the form known as the solid trough construction. The steel work is covered with concrete, which is thoroughly waterproofed with five layers of felt and asphalt compound. This in turn is covered with a layer of protecting bricks laid in sand and grouted. Upon the bricks is tamped the stone ballast, carrying the wooden ties and the rails forming the roadbed. In addition to these improvements the company has erected a new passenger station, of modern fireproof construction; built new repair shops at Tod's Cut and new freight yards at Edgemoor. The total time gained by the new work will be about four minutes.

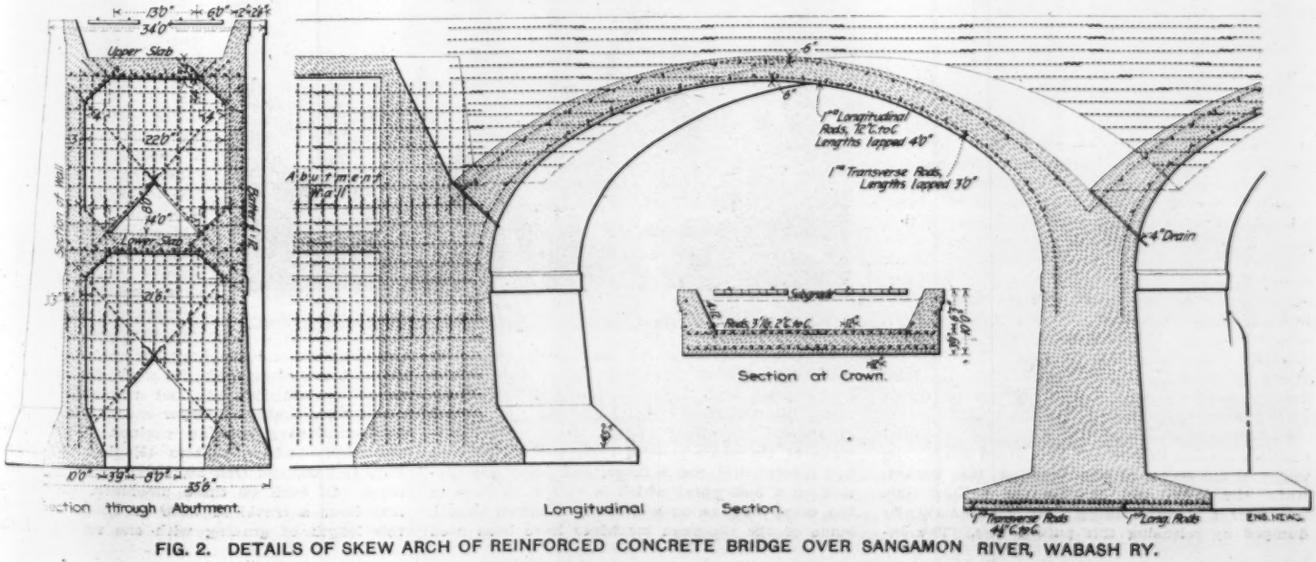

FIG. 2. DETAILS OF SKEW ARCH OF REINFORCED CONCRETE BRIDGE OVER SANGAMON RIVER, WABASH RY.

SCRAPER EXCAVATORS.

A special type of excavating and dredging machine which is now being used somewhat extensively on various kinds of work, consists of a stationary or traveling hoist or derrick handling a scraper-bucket by an arrangement of lines which enables the engineman to control all the operations for excavating, handling and dumping the material. In the Channon and the Page excavators, described below, the bucket is handled from the boom of a traveling derrick, the machine being self contained and moving backward as the work progresses. The bucket and the arrangement of lines as patented by Mr. J. W. Page (Engineering News, March 2, 1905) are used on both these machines, and the buckets are manufactured by Page & Shnable, Security Building, Chicago. Completely equipped excavating machines of this class, including the derrick car, hoist and bucket, are a specialty of the H. Channon Co., 28 Market St., Chicago, and are in use on a number of works of different kinds.

FIG. 1. SCRAPER-BUCKET EXCAVATOR DIGGING AND LOADING GRAVEL.
H. Channon Co., Chicago; Builders.

THE CHANNON SCRAPER EXCAVATOR.—In Fig. 1 is shown a Channon excavator digging gravel for the roadbed of the new electric interurban line of the Marion & Bluffton Traction Co. This gravel pit is near Liberty Center, Ind., and the machine was first used for stripping the material above the gravel. This was a heavy clay, that might in places be classed as hardpan, and we are informed that material that could not be plowed by four horses was successfully handled with this scraper-bucket. The pit is from 25 to 30 ft. deep, and the bucket readily takes the material from this depth and loads it into the bottom-dump cars, which are of 26½ cu. yds. capacity. The number of cars loaded daily ranges from 40 to 60. The train of seven cars is usually loaded in 60 to 75 minutes, including the time consumed in moving the cars. This is considered an excellent performance, in view of the fact that the pit has from 15 to 25 ft. of water, so that the bucket, which is of 1½ cu. yds. capacity, has to be brought close to the bank each time in order to secure a full load, as the gravel washes out to some extent when coming up through the water. The boom is 50 ft. long, which gives a large effective working radius. The weight of the machine in working order is about 35 tons. The Moore-Mansfield Construction Co., of Indianapolis, Ind., has the contract for the work and owns two of the Channon machines.

The main engine is of the Mundy pattern, and has two friction drums and two winch heads; the upper drum is used for hoisting the bucket, while the lower one handles the pulling line. The bucket is self loading, and is automatically dumped by releasing this pulling line. The entire upper part of the machine, including the engine, A-frame and boom, revolves through a complete circle on a 14-ft. circular track, so that the bucket is always balanced, and the machine can excavate or handle material in all directions. An independent engine with compound gearing and link reverse valve gear, is used for swinging the machine, this being done by a wire rope which passes around the turntable. With this arrangement the machine can dig all round itself, can level the ground for its own path and for the tracks; and can deposit the material on either side or in the rear for backfilling, as in sewer or other trench work. The turntable is carried by a center casting and by four 18-in. wheels riding on the circular track. The boom may be as long as 75 ft., and is composed of two timbers, spread apart about 3 ft. 4 ins. at the base and securely tied and braced. It is pivoted on a 3-in. horizontal shaft at the base, and its head is supported by lines from a substantial timber A-frame. The machine does not travel on rails, but its main frame rests on 7-in. maple rollers, with plank runways for the roller path. It travels backward from the work, pulling the bucket towards it in excavating, and hauls itself along by means of cables, leveling the ground ahead of it, as already noted. In a smaller machine of the same general type, the engine does not revolve, but the A-frame and boom are carried on a bull-wheel which is swung by lines in the same way as on a derrick or steam shovel. Some of the Channon machines have been used on government work in the south and reclamation Service work in Montana; others have been used for wet and dry ditch work, ballasting and shipping and loading coal.

FIG. 2. PAGE SCRAPER-BUCKET HANDLING LOOSE LIMESTONE.

These excavating machines are adaptable to various kinds of work: railway grading for cuts and banks, sewer trenching, drainage ditches, levees, gravel pits, and the general handling of material. With the length of boom that can be used, the material need be handled only once in ordinary work, the bucket dumping it into place or into cars. Buckets of the orange-peel or other type and ordinary skips can of course be used instead of the Page bucket for certain kinds of work. The actual working capacity depends upon various conditions of the work and upon the ability of the man handling the levers; with a 1½-yd. bucket two cuts can be made in a minute, but with ordinary work it is estimated that throughout a ten-hour day the average rate would be one cut per minute, or from 750 to 1,000 cu. yds. in ten hours. In the gravel pit work already mentioned 185 yds. were loaded in 60 and 75 minutes, including 10 and 15 minutes for spotting cars and switching. This would be at the rate of about 150 yds. per hour, but this could hardly be maintained throughout a ten-hour day. Some of the advantages claimed for these machines as compared with steam shovels and dipper dredges are that they can use longer booms, can work to depths of 30 or 35 ft., and can be more readily set up, taken down and transported.

THE PAGE SCRAPER EXCAVATOR.—An interesting example of the use of the Page scraper-bucket is on the substructure work for the butterfly dam for emergency control of the flow of the Chicago Drainage Canal, and located just below the controlling works at Lockport, Ill. For this work Page & Shnable, of Chicago, are the contractors, and built their own machines. A stiff-leg derrick with 90-ft. boom handling a 1½-yd. bucket was used for filling a temporary crib cofferdam, but the most interesting machine is a steel revolving derrick handling a 2-yd. bucket and used in excavating the foundation pits in the rock. The character of the material handled is shown in Fig. 2, while Fig. 3 is a view of the derrick. From this it will be seen that the 60-ft. boom is of steel, and is V-shaped in plan, having two latticed legs fitted to opposite corners of the deck and brought together at the outer end, where it is supported from the A-frame. For the hoisting there is a double-cylinder double-drum engine with cylinders 8½ × 10 ins., while the swinging engine has cylinders 6¼ × 8 ins. The derrick revolves on a circular track of 80-lb. rails, 20 ft. in diameter. In excavating the vertical shafts for the anchorage, the bucket was used as an automatic dumping skip. This steel derrick was designed by Mr. J. W. Page, who states that it is easier to erect and dismantle than a wooden derrick of the same size; it can be shipped in members of less length than a flat car, it will not catch fire, and it weighs 40% less than a wooden derrick of the same capacity.

OTHER SCRAPER EXCAVATORS.—In both the Channon and the Page excavators, the machines move along with the work, feeding themselves against the cut, but reference has already been made to scraper excavators operated from stationary hoisting engines. The Bagley and Hammond excavators (Engineering News, Feb. 1, 1906, and Oct. 20, 1904) are both of this class. In each of these machines, the bucket may have a travel of 1,000 or 1,500 ft. and do this length of grading with one setting of the

machine, although in practice the length of cut is generally 300 to 600 ft. The bucket is handled by lines running from the engine to an anchor or deadman. This may be considered to some extent as an adaptation of the cableway system, although the bucket travels on the ground while excavating, hauling and returning. A similar arrangement has been used in the stripping of kaolin clay beds in the South; the bucket excavates the earth and is automatically dumped

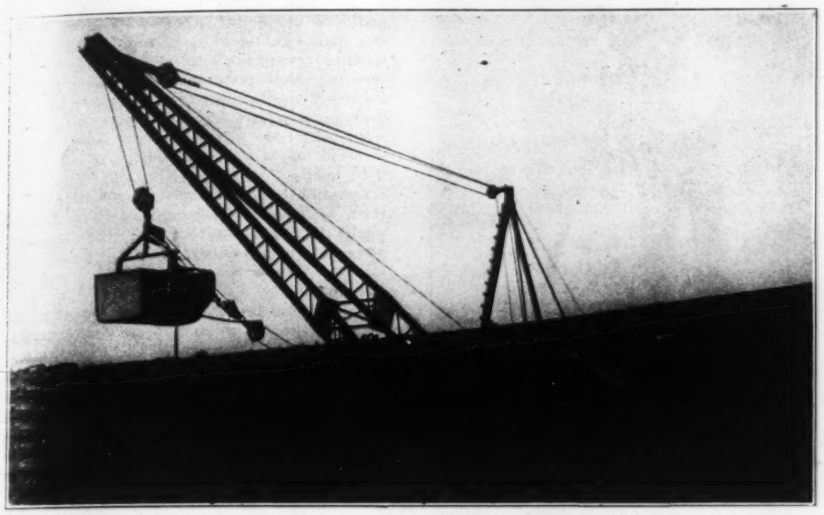

FIG. 3. STEEL DERRICK WITH PAGE SCRAPER-BUCKET AT WORK ON THE FOUNDATIONS FOR THE BUTTERFLY DAM, CHICAGO DRAINAGE CANAL.
Page & Shnable, Chicago; Builders of Derrick and Contractors for Substructure of Dam.

by a short chain attached at one end to the back of the bucket and having at the other end a ring which rides on the hauling rope. Besides the use of scraper buckets, clamshell buckets may be sometimes employed in soft and wet material. Thus some of the embankments of the Key West extension of the Florida East Coast Ry. were built across swampy land by a traveling derrick-car handling a clamshell bucket and running on a track laid along the top of the embankment.

THE BAGLEY GRADER.—This excavating and grading machine, which is noted above (and which was described in our issue of Feb. 1, 1906), is built by the Bagley Grader Co., of Tacoma, Wash., and has been used on a number of works of different kinds. It was employed last season to put in the base of a large embankment at Stockwood, Minn., in connection with grade and line revision work on the Northern Pacific Ry.; the bank is to be from 20 to 40 ft. high, and for part of its length it occupies the site of the existing track. The C. C. Smith Co., of Hawley, Minn., has the contract for the four-mile section which includes this bank, and used the scraper excavator to build the base of the bank to a height of about 10 ft. The 75-HP. engine and 100-HP. boiler were mounted on a flat car which stood on the main track, and the scraper or bucket traveled at right angles to this track, with a maximum haul of 250 ft. A cable 1,500 ft. long was stretched parallel with the track at the rear of the borrow pit and served as the attachment or anchorage for the block carrying the scraper cable, the block being shifted along the fixed cable as the work progressed and the car on the track moved forward. Owing to the soft ground, however, the strain on this fixed cable frequently loosened the timbers or deadmen to which its ends were attached, and when work is resumed in the spring it is intended to secure this anchor cable to piles about 250 ft. apart. It is expected to move 80 cu. yds. per hour with a 3-yd. scraper and four men; or 1,500 cu. yds. per day with a 6-yd. scraper. The larger bucket would, of course, require heavier anchorages for the operating cables, and when tried last season it could not be worked to full capacity for fear of upsetting the car carrying the engine, the rail clamps holding this car to the track being broken several times by the strain. Mr. C. C. Smith considers that a lighter outfit of this kind would be specially adapted to new work where cuts are short, steep and high, and impracticable for teams.

The Bagley grader has also been used on new railway construction work for the Chicago, St. Paul, Minneapolis & Omaha Ry. by Winston Bros., contractors, Minneapolis, Minn. Mr. H. E. Stevens, of this firm, states that the scraper was used in very hard material, for which it was not well adapted, but that under proper conditions of material and length of haul it could prove a valuable plant for the movement of 400 to 800 cu. yds. per ten-hour day. Fig. 4 shows a view of this work at an 80-ft. cut and 80-ft. bank near Minneopa, Minn. The steam shovel, with 2½-yd. bucket, is working the main body of the cut, while the triangular section of the top slope beyond the reach of the shovel is being taken out with the scraper. The 3-yd. scraper is shown at the edge of the dump, and behind it is the trench which it has already cut; the scraper works parallel with the track (or the axis of the cut) in this case, and is operated by the 50-HP. engine (10 × 12-in. cylinders) and vertical boiler (60 × 108 ins.) at the left of the view. The slack cables will be noted lying across the ravine, the engine being about 400 ft. from the grade point of cut and fill, and the haul of the scraper being from 100 to 400 ft.

TESTS OF COMPOUNDING AND SUPERHEATING ON FRENCH LOCOMOTIVES.

The Paris & Orleans Ry., of France, has fitted the Schmidt superheater (Eng. News, June 22, 1905) to five simple engines of the ten-wheel (4-6-0) type built by the Baldwin Locomotive Works in 1900. The firebox and smokebox tube plates were replaced by new ones, and 96 of the 2-in. tubes were replaced by 21 tubes 5 ins. diameter, in which were placed the superheater tubes; these tubes connect with a header in the smokebox. A Schaeffer & Budenberg pyrometer was attached to indicate the temperature of the steam. In order to test the results, observations were made on the regular runs from Paris to Orleans and return with fast passenger and mail trains, making an average speed of 40 miles per hour. These trips were made with the converted engines and with others of the original type, the railway company's dynamometer car being attached to the tender in each case. The fuel comprised a mixture of 60% of English coal and 40% of coal briquettes. The temperature of the steam ranged usually from 250° to 270° at starting and from 300° to 350° when running; it even attained 370°, but this caused leakage of steam and the lubricating oil smoked, and it was necessary to reduce it to 350°. To ensure the proper operation of the superheater it was found necessary to clean its tubes at each end of the run, using special cleaning rods. The leading particulars of the engine are as follows, the figures in parentheses relating to the engines with superheaters:

Driving wheels	5.61 ft.
Cylinders	19.3 × 26.4 ins.
Heat. surface, firebox	129.12 sq. ft.
Heat. surface, tubes (1,338.54 sq. ft.)	1,685.87 sq. ft.
Heat. surface, total (1,467.66 sq. ft.)	1,814.99 sq. ft.
Superheating surface (295.90 sq. ft.)	
Grate area	26.47 sq. ft.

A summary of the results of the tests shows that the simple engines fitted with superheaters developed an average economy of 20.8% in water and 16.6% in fuel, as compared with similar en-

FIG 4. THE BAGLEY SCRAPER-BUCKET EXCAVATING THE TOP OF SLOPE OF A DEEP CUT: CHICAGO, ST. PAUL, MINNEAPOLIS & OMAHA RY.
Bagley Grader Co., Tacoma, Wash.; Builders of Scraper.
Winston Brothers, Minneapolis, Minn.; Contractors.

gines without superheaters. As the boilers of these engines had shallow fireboxes and a forced draft, the use of the large tubes diminished the draft and improved the working of the boiler. It was not thought that an equally high saving in fuel would be maintained with other engines having deeper fireboxes. A comparison of the results with those of the latest compound engines on this road indicate about the same consumption of water on both engines, but an economy of at least 8% in fuel consumption in favor of the compounds as compared with the simple engines with superheaters.

A NEW FORESIGHT FOR SETTING TRANSIT POINTS.

By FRED. J. WOOD,* M. Am. Soc. C. E.

Over a year ago the writer began to give more attention to the methods employed in setting points ahead of the transit on location surveys, not feeling satisfied with any of the usual methods for various reasons, especially on account of the time lost in checking. Especially did I feel this attention necessary as I was then engaged on some railroad locations on which tangents of from three to twelve miles in length were developed. As a result the instrument shown and described below was designed. Having now had it in use on practical work for nearly a year, I feel justified in offering it for the consideration of engineers, as I can vouch for it as a rapid, accurate and labor-saving device. As already intimated, this instrument is used only to facilitate the setting of hubs and tacks for transit points, replacing the time-honored range poles; it makes amends for the extra load carried by the accuracy and rapidity of its operation, rarely requiring more than one repetition for checking.

The general appearance of the instrument is shown in the photograph Fig. 1, in which the operator is shown watching the signals of the transitman and moving it "just a hair" to one side or the other, as directed. Fig. 2 is a front elevation and cross-section, the latter somewhat diagrammatic.

The base of the instrument is a board 18 ins. long by 5 ins. wide and 1 in. thick, mounted on an ordinary tripod with leveling screws. In this base are set two level glasses at right angles to each other, and on the top two small brass racks are laid. A V-shaped groove is cut along each edge in which the guides of the carriage travel. The carriage is in two parts, first the upright face on which an oval target is painted, and second the portion designed for controlling the movement and attaching to the base. As indicated in the sectional view, the carriage is moved by the two brass gears which engage the racks in the base. These are actuated by the thumb and forefinger turning the knurled wheel on the end of the shaft carrying the gears, which shaft is fixed in position on the carriage.

The transitman readily sees the target at any distance which is permissible, and quickly brings the vertical line in line with his cross hair. When he gives "All right" the target remains stationary, and none of the troubles due to the chainman's involuntary side movements are felt; up to this point, too, the effect of a fairly brisk wind can be ignored. Then by means of a plumb-bob suspended by a silk line directly in line with the center line of the target, the exact point for the tack can be determined.

For various reasons this device does not seem suitable for a patent and the writer takes pleasure in offering the accompanying drawings for the use of any engineer who cares to have one made. The instrument so far in use is made of black walnut, and, because a second-hand tripod could be bought at a reasonable price, was secured complete for about $25.

Fig. 1. A Useful Transit Foresight.

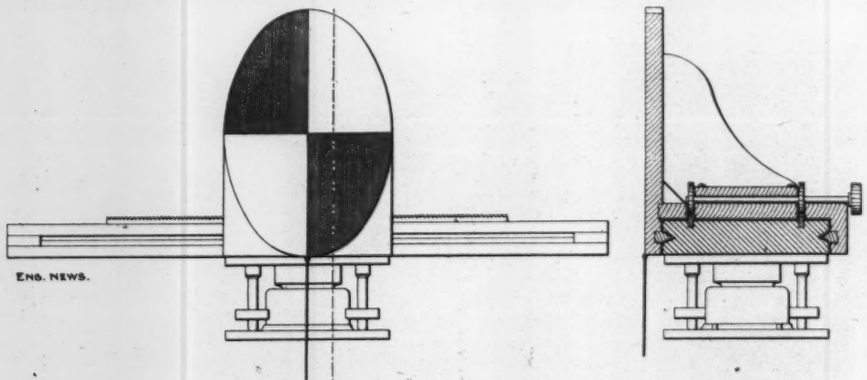

FIG. 2. FRONT ELEVATION AND CROSS-SECTION OF WOOD'S TRANSIT FORESIGHT.

*Chief Engineer, Boston & Providence Interurban Electric R. R., Foxboro, Mass.

COST OF EARTH AUGER BORINGS ON THE NEW YORK STATE BARGE CANAL.

By EMILE LOW,* M. Am. Soc. C. E.

In Engineering News of Jan. 17, there appeared an article on the methods and cost of wash drill borings, as employed on Section 5 of the New York State Barge Canal work.

The writer presents below data relative to borings made with fence post hole diggers, or so-called "earth augers," with which tools some 450 test holes were dug on this same section.

The earth augers first used were made by the W. Eddy Plow Co., of Greenwich, N. Y., and consisted of a light steel cylindrical pod, 6 ins. in diameter and 5 ins. long, not including the scraper bottom edge, composed of 5 saw-shaped teeth 2 ins. long. These teeth were bent inward 1/2 in. or less, depending on the character of the material bored. The pod was riveted to a 1-in. rod, made up of a fork about 18 ins. long and an 8-ft. piece of 1-in. gas pipe. There was also an extra piece of pipe 8 ft. long, to be attached when holes were over 8 ft. deep.

Upon trial it was found that the steel in the pod was too light. Another objection was that the pod was fastened permanently to the rod, making transportation inconvenient, as well as repairs. New pods of heavier steel were made by the Rome Locomotive & Machine Works and permanently riveted to a short fork, provided with a screw thread, so the same could be screwed into a standard section of 1-in. gas pipe, 8 ft. long.

Suitable handles were provided to grip the pipe, with which the earth auger was turned. It ought to be mentioned that the term "earth auger" is a misnomer, as the apparatus is not an auger, only bearing a slight resemblance to the same.

In making test borings the operation is extremely simple, a hole 6 ins. diameter being bored. This is accomplished by turning the auger in the ground until the pod is full of earth, then lifting it out and emptying, and continuing until the required depth is reached. In suitable soil holes 16 ft. deep can readily be "bored."

As the material is brought up the character of the same is noted and recorded, as also when it changes, the thickness of the stratum is measured, all of which data is kept in the same manner as noted in the article referring to wash drill borings. As the holes were all shallow, the records of three holes were kept in one sample box, a scale of 2 ft. to 1 in. being used in preserving samples.

The holes were placed at 200 ft. horizontal intervals, there being 450 holes, having a total depth of 5,967 ft. or an average depth of 13.26 ft.

The accompanying table gives the cost of these borings:

	Total cost.	Per lin. ft., cts.	Remarks.
Bottles, sample...	$14.07	0.0024	
Boxes, sample...	25.13	0.0042	
Cartage	.25	0.0000	Per day, force
Corks	.90	0.0002	employed: 3 la-
Express	.40	0.0001	borers, at $2.80;
Freight	.50	0.0001	at times, 1 horse
Fuel	1.20	0.0002	and buggy, $2,
Labels	1.20	0.0002	for transporta-
Labor	881.00	0.1476	tion of men and
Miscellaneous ...	.35	0.0001	tools.
Repairs	7.15	0.0012	Daily progress,
Teams	127.50	0.0213	3 holes or 40 ft.
Tools	31.06	0.0052	
Traveling exp....	....	.....	
Total	$1,090.71	0.1828	

Holes drilled	450
Feet drilled	5,967
Average depth, ft.	13.26

Material: Muck, sand, clay and gravel.

THE REINFORCED-CONCRETE FRAMEWORK of a department store building, the Stewart Building, now being erected in Louisville, Ky., has the following principal features: The building is 108 x 180 ft., seven stories high. The floor spans are rather long, to minimize the obstruction of floor space by columns. As the owner desired the depth of beams to be held within fixed limits, more reinforcing was required than economy demands. The beam spans vary from 18 to 25 ft. and the intermediate spans from 18 to 22 ft. The floors were designed for 150 lbs. live-load per square foot; tests to twice this live-load were satisfactory, with very little deflection. All beam and slab reinforcement is Johnson corrugated bars, and the designs were made by the Johnson formula; a 1:2:5 gravel concrete was used. The columns are hooped with ⅜-in. round rods spaced 5 to 8 ins. on centers; they are made of 1:2:4 gravel concrete and are proportioned for a maximum compression of 750 lbs. per sq. in. The floors are generally covered with 3 ins. of cinder concrete, in which nailing strips for maple floor finish are embedded; but the second floor has in place of the concrete fill an 8-in. fill of dry cinders, to contain the large distribution pipes. The exterior of the building is of brick, with terra-cotta trimmings, and the exterior beams and columns are molded to fit the reveals in the brickwork. On one face (east) the concrete girders are left exposed. A reinforced-concrete chimney 140 ft. high is erected in one corner of the building; it is designed for future extension to 175 ft. high. McDonald & Dodd are the architects. The reinforced-concrete work was constructed by The Oliver Co., Knoxville, Tenn.

*Rome, N. Y.

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The increase in the mercantile insurance rates of Montreal, just made by the Canadian Fire Underwriters' Association, is a fresh and should be a convincing lesson to many of our municipalities of the importance of keeping their waterworks in a condition adequate to meet the needs of fire protection. There have been numerous breakdowns of water-works pumping engines at Montreal this winter, some or all of which should have been anticipated by long-needed repairs and the provision of additional pumping capacity. Increases in insurance rates seem to be the only prod that will bring some of our cities to a realizing sense of the necessity of giving close heed to the urgent needs of their water departments.

The annexation of Lower California to the United States in order to facilitate the future control of the Colorado River, was advocated editorially in our issue of Feb. 21, 1907. It has since been proposed—with how extensive a backing we cannot say—that California be divided into two States, one to embrace, and be called, Southern California. Should this be done Lower California, in case of annexation, might be added to the new State. The proposal for dividing California is outlined in some detail in the Los Angeles "Express" of March 8, 1907. The project is of no great concern to engineers, as such, except in its relation to the control of the Colorado, and except that the new State, if created, would be unique in that it would eventually comprise one of the most remarkable areas of irrigated land in the whole world, and would also include a considerable number of notable hydroelectric power plants. Inasmuch as the section of the country in which irrigation is paramount demands special laws for the control of natural waters, there would perhaps be some advantages in having the present State of California divided into an irrigated and a generally non-irrigated area. California now contains an area of nearly 160,000 sq. mi., and has a length of 800 miles and a coast line corresponding in general to the distance between Providence, R. I., and Savannah, Ga. The populous southern sections of the State are separated by 500 miles from their State capital. San Bernardino County, alone, has an area of 20,000 sq. mi. Such long distances and vast areas may well suggest the division of California, but we do not look to see it effected very soon.

The consolidation of Pittsburg and Allegheny, in accordance with a recent legislative act just pronounced constitutional by the Pennsylvania State Supreme Court, seems more justifiable than the creation of many of the greater cities that have been proposed in recent years. The two cities already have many things in common, and there are others, particularly some of their public works, that could be provided far more advantageously if carried out as one rather than two undertakings. This is particularly true of the public water supply. Both cities have been so typhoid-ridden for many years that their names have become a byword, and a visit to the cities by residents of other communities has been attended with grave personal risk. Pittsburg has a large filtration plant well under way. Although this has been designed, we suppose, with a view of supplying Pittsburg, alone, yet the consumption and waste of water in both Pittsburg and Allegheny is so high that, if waste-restrictive measures could be adopted, the full capacity of the plant now being built would certainly go far toward supplying both cities. Among the other public services that can advantageously be provided, or at least supervised, better under consolidation, local transportation may merely be mentioned in passing. The consolidation puts Pittsburg at one great leap well toward the head of the list of the largest cities of the country, in point of population, as it long has been as an industrial center. There is reason to hope that its civic spirit and its municipal betterments will hereafter keep better step with its industrial greatness than has been the case throughout much of its history.

The concern with which the daily press of New York City has looked upon three or four cases of typhoid fever in the small village of Katonah, in the Croton drainage area, promises well for the reduction of water-borne typhoid fever in the future. Time was when a hundred or several hundred cases of typhoid might threaten a community before anyone would be officially aware of their existence. The three or four cases at Katonah were almost immediately brought to the attention of both the Water and Health Departments of New York City, and there is every reason to believe that such precautions are being taken as will protect the New York water supply from danger. Even should every one of these cases be allowed to infect the New York water supply directly, the danger to the city would be infinitesimal, compared with that to which hundreds of cities and towns in the United States are continually subjected through utter neglect to provide a sanitary supervision of their public water supplies. Small as the danger is from these typhoid cases at Katonah, they should serve to call public attention to the remarkable course of events in that hamlet. Some years ago the city condemned the property of nearly all these villagers, for the very purpose of protecting the water supply of New York. The property holders pocketed large sums of money, and immediately proceeded to lay out a new village a few hundred feet distant and within the same drainage area. Instead of providing a sewerage system with the most improved means of sewage treatment, cesspools were permitted. On the face of it it certainly looks as though New York City, after spending so much money to condemn one village, should have taken more care to see that not even remote dangers were permitted in the establishment of a new village.

The New York State Department of Health deserves double or quadruple the $85,000 appropriation it is now asking from the State legislature for its next fiscal year. The Department is responsible in no small degree for the health of 8,000,000 people. It has some, and should have more, jurisdiction over all the public water supplies of the State. It has a little, and should have greatly increased, control of all matters relating to the pollution of streams and lakes. It does a small but creditable amount of laboratory work, but nothing like what it should do. A large part of its efforts are, of course, directed specifically to the prevention of communicable diseases, but here, also, it could and should do more. The Department had an appropriation of less than $60,000 last year, as compared with $350,000 at the disposal of the Pennsylvania State Department of Health. The New York Department of Health is asking for $10,000 for its Sanitary Engineering Division. This is a very small sum when it is considered that the division has to pass on all plans for new sewerage and disposal systems; is preparing plans for sewerage and sewage disposal of State institutions; investigates complaints of stream pollution, garbage disposal and other nuisances; investigates typhoid epidemics; advises municipalities on sewerage and water supply matters; and is making sanitary maps of the various drainage areas of the State. The present outcry against stream pollution makes it particularly important that some competent public authority should thoroughly investigate that subject in all its many bearings, both general and local, for otherwise serious error and grievous injustice is bound to result. In conclusion, we may state that for years the New York State Department of Health, for reasons that need not be gone into here, was grossly inefficient. It is still crippled through lack of authority and funds. Since its reorganization it has done much good work and has outlined much more that it can and will do if the necessary money is made available. The great Commonwealth of New York should provide the money unstintingly.

Construction failures of reinforced-concrete work are not localized to the United States. If we are sometimes tempted to think them an endemic disease in this country, we may feel slightly reassured by noting that conditions in some European countries are not radically different. Germany, Austria and Switzerland have had fairly regular failures, from mere floor failures to the collapse of heavy roof-girder construction. Poor cement, poor design and poor execution have all played their part as causes. The Slav territories of Russia and Poland have had a considerable number of failures in recent times, according to a Polish source quoted by Prof. v. Thullie in "Beton und Eisen." A late case, for example, occurred in the construction of a building for the St. Petersburg Technical College a few months ago, when a reinforced-concrete column crushed down after the floor centering of the floor above was removed. The view appears to be held by some persons abroad that the root of the trouble is the non-existence of standard or authoritative specifications for design and construction in reinforced-concrete. Perhaps there is just as much divergence [not necessarily of opinion, but of practice] as to safe stresses, suitable "factor of safety," and the like, as in our own building circles. One of the bad incidental conditions also affects American work. There is a very strong and very successful tendency to conceal all knowledge or facts of such failures, even their existence; foreign engineering circles are to a large extent unaware of the frequency of these accidents. This in particular is a condition that must be remedied; the cooperation of all the progressive elements of the profession in this effort is a very necessary thing.

In illustrating the "Transporter Bridge" at Newport, England, in our issue of Oct. 11, we pointed out that this system of over-water transport is of exceedingly limited traffic capacity, and consequently will find useful application in very few locations. Attention is again called to this subject by receipt of a paper read before the Institution of Civil Engineers describing another transporter bridge crossing the River Mersey and the Manchester ship canal at Runcorn, a few miles above Liverpool. This structure has a clear span of 1,000 ft. and its floor is 82 ft. above the water. The suspended car is 55 ft. long and 24 ft. wide. It has a 15-ft. roadway and a covered shelter or passenger cabin 22 ft. long and 8 ft. wide occupies part of the deck. The

only other data as to traffic capacity given in the paper are as follows:

> The bridge was formally opened for public traffic by Sir John T. Brunner, Bart., M. P., on the 29th May, 1905. During that day passengers were taken across the river at the rate of more than 2,000 per hour, in addition to a large number of vehicles, and upon several trips there were about 600 passengers and two vehicles on board. When working in parallel, with a load of about 10 tons, the time occupied in crossing the 1,000 feet was 1¾ minute; but as the traffic does not demand this quick running, the time now occupied is between 3 and 4 minutes, the power required varying from 25 B.HP. upwards according to the pressure and direction of the wind.

From these figures, allowing for time for loading and unloading at terminals, it may be judged that a round trip in 8 minutes or about 7 round trips per hour would be the limit of the capacity of this bridge, and accepting the figure given of 600 passengers, the maximum traffic capacity in one direction can hardly exceed about 4,500 per hour. To say that this is a very meager result for an expenditure of some $650,000 (the total cost of the bridge) appears to put it very mildly.

In the discussion on the paper before the Institution this very point was brought out, Mr. Jas. C. Inglis remarking that "the fact that only a single line of communication had been provided at a cost of £133,000 suggested that the limit of development of the method has been reached." The remarks of Sir Benjamin Baker in the discussion are also worth quoting:

> The transporter bridge system would suffice only where the traffic was not excessive, because, as Mr. Inglis had pointed out, the accommodation was not nearly so good as that on an ordinary bridge. Quite recently he had had to consider a number of alternative schemes for the traffic between Barrow-on-Furness and Walney Island, and he had submitted transporter-bridges and ferry-boats with raised decks; but none of these would meet the case, for the same reason that railways in London had great difficulty in dealing with the suburban traffic—everybody wanted to travel at the same time. After going into the matter in great detail with the local authorities the conclusion had been come to that a transporter-bridge would be useless where thousands of workmen wanted to cross to their dinner at the same hour, with only limited time at their disposal for getting to and fro.

The leveling tests conducted by Prof. John C. Tracy, of the Sheffield Scientific School, which are reprinted on another page of this issue, go to show a very unnecessary refinement which is common in work of a secondary nature. This is the use of a target rod in short-distance readings (up to 300 ft.) in any but the most precise work. Average probable maximum errors in reading a target rod for 100, 200 and 300 ft. were found to be .00158, .00194 and .00303 ft., respectively, while for the same distance on a "speaking" rod the errors were .0035, .0048 and .0065 ft. respectively. It must be understood that these tests were carried on in the most unfavorable manner, and that the errors given are maximum, so that the data can not be considered absolutely, but only relatively. Prof. Tracy also states that the non-target tests were carried on under conditions of much greater inaccuracy than the others, so that the relative error is even smaller than would appear on the face of the problem.

There are two other items in such an investigation that would be of help in determining the relative value of target and non-target rods.

In order to get an idea of the probable error in actual work of this sort, experiments showing the relation between errors occurring in work of experienced surveyors and in that of students just starting in the study of the work, such as were used in these tests, would be interesting. There is no doubt that this would appreciably reduce the maximum error.

On the other hand it might be noted that a large element of accuracy of the target rod is due to the aid of the target in plumbing the rod, especially when the two-faced target is used. To get the exact relation between the two styles of level-rod reading it would be necessary to take a series of readings by both methods on the same point and compare the two. That is, the non-target readings, while agreeing among themselves quite closely, might all be in error from the true elevation, owing to the lack of verticality of the rod.

Both of these tests are outside the province of Prof. Tracy's experiments, but it is probable that the first would reduce the maximum error in each case to a point so low that even with the gain in accuracy due to more correct plumbing of the target rod the difference between the two methods of reading would be still well under 0.01 ft. Therefore it is safe to say, as a result of these investigations conducted under the most unfavorable conditions, in some cases up to as high as 1,200 repetitions, that in short-sight level work, where elevations are required to hundredths only, the use of the target with its added trouble, both in setting and reading, is a loss of time unjustified by any additional accuracy.

THE LIABILITY OF REINFORCED CONCRETE TO ELECTROLYTIC DAMAGE.

One of the strong forces working for the spread of reinforced-concrete construction is the fact that the concrete is looked upon as a perfect protector against corrosion of the imbedded steel. It is held, on the basis of much cumulative evidence, that steel encased in sound, dense concrete will not rust, under any provocation, and that even the much-feared and little-known action of "progressive corrosion" will fail when a rusty bar of steel is thoroughly covered with good concrete. This belief, developing at a time when the subject of rusting of steel structures was arousing a good deal of concern and when a suitable paint protection was being sought quite anxiously, had much to do with the sudden enthusiasm for reinforced concrete which swept over this country in the last half dozen years. The belief is a well-founded one. We have every reason to believe that atmospheric corrosion is completely kept away from the imbedded steel of reinforced concrete, and that, provided mechanical deterioration does not change the condition of such a structure, it will in effect be of indefinitely great durability.

But the action of *electrolytic* corrosion upon steel appears to penetrate through the surrounding concrete, according to experiments which Mr. A. A. Knudson, of New York City, recently reported to the American Institute of Electrical Engineers. Mr. Knudson found that (1) Concrete permeated with water is a fairly good conductor of electricity, at least 10 to 15 times as good a conductor as dry concrete; (2) If electric current in some way enters a steel member encased in concrete and then passes out of the steel through the wet concrete, the metal is corroded just as iron or steel buried in soil is corroded at the points where electric currents pass from the metal to the soil; and (3) During this electrolytic corrosion of the steel there proceeds also a destructive action within the concrete, whose effect is to soften, disintegrate and disrupt the concrete. These observations are evidently of vital bearing on the question of the durability of reinforced concrete under the ground surface or under water. For, concrete in such locations will generally be exposed to water in sufficient degree to be practically water-soaked, and the abundance of "stray" current in all regions where trolley lines operate provides ample opportunity for the establishment of the requisite electrolytic conditions. We therefore direct attention to the original paper describing the experiments in question, in "Proceedings of the American Institute of Electrical Engineers" for February, 1907.*

The method of the experiments from which the above conclusions were drawn was about as follows: Using a metal water-pail as a mold, several blocks of 1:1 Portland cement-sand concrete, some 10 ins. in diameter and 12 ins. high, were molded; in the center of each block was a piece of 2-in. wrought-iron pipe extending vertically about 8 ins. into the block. When these blocks were about three years old they were set each in a tank of water, and direct current was led into the iron pipe in the center of each block, the negative electrode being a piece of sheet-iron immersed in the tank. One block was thus tested in fresh water, and another in sea-water, while a third was similarly immersed in sea-water, but was not subjected to the action of electric current. The latter block was perfectly sound after 30 days, and the imbedded pipe was perfectly bright. The two other blocks were easy to break open, in fact the blocks had developed cracks during the test; there were yellowish deposits, apparently iron-rust, in these seams, where also the concrete was so softened that it could be readily cut or scraped with a knife; and the pipes enclosed showed considerable corrosion, their loss of weight being in excess of 2%. The current which caused this destructive action was 0.1 ampere, acting continuously during 30 days. It may be noted that the electrical resistance of the concrete rose greatly during the test, the final value being ten times the initial resistance and roughly equal to the resistance of dry concrete. After these experiments the same procedure was applied to similar blocks of a standard Rosendale cement [but these blocks were apparently only a month old when tested]. The results were very closely the same. Cracking of the concrete appeared as early as the sixth day of the test, and by the 18th day was so serious that it seemed as if the blocks might easily fall apart. In this test, moreover, one of the pipes showed concentrated corrosion [analogous to the "pitting" action in underground "electrolysis"], which formed a hole 1-in by ⅝-in. through the 9/16-in. wall of the pipe.

These observations merit the serious attention of reinforced concrete engineers. There are many kinds of structures in reinforced concrete so situated that destructive action of the kind shown is possible. Perhaps as favorable a case as any is offered in long conduits or sewers located [as most of them are] in a trolley territory; in such it may be expected that the stray return currents which the trolley roads carelessly scatter about will seek the continuous longitudinal reinforcing rods as a return path, and later, in leaving the metal to reach the powerhouse, will set up electrolytic corrosion as described. The destructive effect, especially the disruption of the concrete, will, if it is actually realized, be of very serious moment.

The observations recorded require confirmation by other experiments, of course. More than this, there are related questions that require investigation. It will be important to know how the action varies with the character, density, etc., of the concrete. The blocks tested were probably made without special care to secure a dense concrete, and it may be that in actual reinforced-concrete construction a more resistant material is produced. The effect of surface treatment intended to produce an impervious concrete should be studied. It would also be interesting to know whether a surface coating of tar, for example, would act as an insulating barrier to keep away electric currents and thus serve as protection. Experiments should also be made to explain the nature of the observed disintegration of the concrete. Finally, the condition of a reinforced-concrete structure, as a retaining wall, a foundation or the like, lying in the path of stray currents but not parallel to their flow for any distance, should be studied with respect to danger of electrolytic corrosion, especially when, as usual, none of the reinforcing metal extends to the surface of the concrete or otherwise has an easy path of entrance for the currents. A case of probable electrolytic damage to a reinforced-concrete bridge abutment, mentioned in the paper already cited, is of little more than suggestive value in this direction.

The showing that electroylytic damage may affect metal imbedded in concrete just as it does bare metal brings again to mind the unsatisfactory state of the whole subject of underground electrolysis. Careful observation and experiment have shown that enormously extensive injury has been done to underground metal structures by the unguarded and unconfined return currents of direct-current trolley railway lines. As a result, several earnest, energetically prosecuted judicial actions have been brought to fix the responsibility for this injury and if possible to stop its continuance. But, strangely, it

*This copy may be obtained on application to the American Institute of Electrical Engineers, 33 West 39th St., New York City, for the price of fifty cents.

has proven impossible to bring these actions to an end. The world appears to await an automatic settlement of the question; the disappearance of electrolysis, perhaps. Much was hoped, in the past, from the protection afforded to underground steel by concrete, which hope would logically lead to the virtual replacement of underground steel by reinforced concrete, or at least the encasement in concrete of all steel which could not be thus done away with. In the light of Mr. Knudson's observations this hope fades away. It is fairly clear that underground pipes will continue to be needed. Must we look toward alternating-current traction as a final remedy? A paper appearing in the same publication with that of Mr. Knudson, on "Alternating-Current Electrolysis," by Mr. J. L. R. Hayden, contributes to existing evidence that with alternating current in place of direct current, electrolytic effects are reduced to an almost vanishing percentage. Direct current is conceded to have some distinct advantages for city traction purposes. So far as known, it will always give rise to electrolytic damage unless the insulated return, as embodied in the expensive conduit system and the much cheaper double-trolley system, be adopted. Since the electric railway fraternity apparently has set its will firmly against the double-trolley system, relief by this means is not to be expected, in view of the unfortunate state of the electrolysis litigation. Are we, then, compelled to look to alternating current as the final remedy?

LETTERS TO THE EDITOR.

The Trouble With the Railways.

Sir: Referring to the editorial in your issue of March 7, 1907, beginning "What Is a Railway?" the trouble is that most national, state and municipal legislation has for its principal object "regulating" and in various ways harassing the corporations, and thus injuring their credit and restricting the earning power of the railways. The investor and small stockholder does not know what is going on. The "Haute Finance" (as Dooley calls them) in the management, through the suppression or manipulation of information that ought to be the common possession of all stockholders, "whipsaws" and generally "fimflams" the small stockholder or investor. As a general proposition, the public is not being injured by the rates charged, or service rendered by the railways, but by "hammering" the corporations they further injure the stockholders already "stung" by speculating management. They strike down the innocent; the guilty escape.

Respectfully,
Calvin E. Brodhead.

East Mauch Chunk, Pa., March 8, 1907.

Topography with an Abney Clinometer.

Sir: Referring to the letter, "A Method of Taking Topography with an Abney Clinometer Level," in Engineering News of March 7, 1907, if Mr. V. S. Veazey will consult p. 665 of your issue of June 22, 1905, he will note that his method is fully described there, as also a scale which is an improvement on his table. I might add that I am the "Engineer" subscribed to that article.

Yours truly, Emile Low.

Rome, N. Y., March 8, 1907.

Sir: In regard to the method of getting topography on railroad location with a clinometer, advocated by Mr. V. S. Veazey in your issue of March 7: Aside from the large liability to error due to measuring the angle of slope with a small arc, the amount of time required to plat the notes in the office is a serious objection. The method advocated by the writer in previous communications on this subject, and in his book on "Railroad Location, Surveys and Estimates,' is not only liable to be more accurate, but also, is the cheapest; the average length of time covered by one topographer and one assistant in any kind of country being at least three-fourths of what the transit party can run in, and the notes are in such shape that the day's work of one topographer can usually be transferred to the map by the draftsman in about two hours. The method referred to as advocated by the writer is a case of the "survival of the fittest," all the other methods having been tried and discarded long ago by most of the experienced locators.

Yours very truly.
F. Lavis, M. Am. Soc. C. E.

42 South Tenth Ave., Mt. Vernon, N. Y., March 7, 1907.

Tie Rods in Street Railway Track.

Sir: In your issue of Feb. 28 I notice a letter from Mr. Horace Andrews on tie rods in pavements.

It does make more work to pave with tie rods, and also necessitates a little wider joints, but if the pavement is grouted with first-class cement, its life will not be lessened. Naturally the paving engineer objects to the tie rods, as also does the contractor doing the work; but to the railroad engineer the safety of the passengers is of the first importance.

Tie rods greatly increase the safety of the track, and any device which will do so should certainly be used by the railway company, even if the paving engineer does not like the looks of the pavement as well. I have in mind a stretch of girder rail track in an unpaved street, joints butted up tight and welded, only the head and tram of the rail being exposed to the sun; no trouble has been experienced with this track getting out of line, which seems to prove that after all the pavement does not have to stand much strain with only the head and tram of the rail exposed. The great importance of the tie rods is to resist the tipping of the side bearing girder rail as the cars pass over the track.

In the case of a sand filled pavement, if the tie rods do increase the cost of maintenance, the railway company usually has to maintain the pavement in its tracks, and would rather pay out small sums for maintenance than large accident claims.

If municipalities would allow the use of the ideal rail, which is the center bearing T-rail, the tie rods could be more safely omitted. In this connection I would call attention to the track construction in the city of Milwaukee, a description of which is given in the "Electric Traction Weekly" of Feb. 28, 1907.

Yours sincerely,
E. P. Roundey.

Syracuse, N. Y., March 5, 1907.

The Growth of Los Angeles and the Proposed Aqueduct.

Sir: I have noted your article on the proposed Los Angeles Aqueduct, together with your editorial thereon, in your issue of Jan. 24, 1907. You state in your editorial as follows: "This is indeed an ambitious project for a city which had, in round numbers, a population of only 50,000 in 1890, and 100,000 in 1900."

These figures are correct, but a most marvelous growth of the city has occurred since the year 1900, both in population and the assessed valuation of its property. As you refer to this projected work as a very great undertaking for a city of this size—all of which is true—I would be obliged if you would publish the accompanying diagrams of population, water consumption and assessed valuation, which bring this information down to date, in order that the magnitude of our efforts may not be exaggerated in the minds of your readers.

Thanking you for your very kind article, which has been highly appreciated in our city, I remain,

Yours very truly, Wm. Mulholland,
Chief Engineer, Los Angeles Aqueduct.

Los Angeles, Cal., Feb. 26, 1907.

[The diagrams sent by Mr. Mulholland (not reproduced) show very rapid increases in population, total water consumption and assessed valuation. The population in 1905, according to unofficial local censuses, is placed at 160,000, and in 1907 at 240,000. The present rate of increase is stated at 36,700 per year, which, if continued, would give a population of 925,000 in 1925. At a probable future annual increase of 25,700, the population in 1925 would be 700,000.

The average daily per capita water consumption between May and October is now 190 gals. It is thought that by thorough metering the future consumption can be reduced to 150 gals., which would require a total daily supply for the summer months of 105,000,000 gals. for the estimated population of 700,000 in 1905.

The assessed valuation of Los Angeles was upwards of $60,000,000 in 1900, about $125,000,000 in 1904, and somewhat over $200,000,0000 in 1906.—Ed.]

Formula for Conditions of Economy in Reinforced Concrete.

Sir: The writer notes Mr. Church's letter to you on "The Formula for Conditions of Economy in Reinforced Concrete," appearing in your issue of Feb. 28 (see p. 245), in which he points out similarity of the writer's fundamental equation for cost of concrete beams with his. The writer was aware of Mr. Church's article in "Transactions American Society of Civil Engineers" for June, 1906, and also of the article by Mr. Merriman on the same subject in that issue, when writing his paper on "Economic Design of Reinforced Concrete." The writer, however, developed his fundamental equation independently and was not aware of its similarity to Mr. Church's equation (10c) until his attention was called to the matter by Mr. Church's letter.

Mr. Church in his equation (10c) makes the stress in concrete the variable in the right hand member, while the writer makes the stress in steel the corresponding variable in his equation (1). This is a very essential difference mathematically and practically, because when the stress in the concrete is varied over considerable ranges economy requires the proportions of aggregates to change which make the modulus of elasticity of the concrete a variable. If no assumption is made prior to solution as to the grade of concrete, the right member of Mr. Church's equation (10c), therefore, contains two variables. If, on the other hand, it is assumed that the modulus of elasticity of the concrete is constant, the computed economic stress will not necessarily or usually fall within the limits of variable working stress for the corresponding grade of concrete. It is for these reasons more satisfactory and definite to avoid these complications by assuming the stress in steel variable and solving for the general condition of economy given by the writer's equation (2). This equation can then be solved for any important mixture of concrete.

Mr. Merriman in his very direct and lucid treatment of the problem assumes tension in a portion of the concrete beam. This assumption is not in accordance with practice and greatly changes the equation of relation of quantities for economy and produces considerably different results.

In the development of the paper on "Economic Design of Reinforced Concrete" it was the writer's aim to present a brief, clear statement of the problem based on the formulas most generally in use and to give tables to show its practical application.

Very truly yours,
F. W. Hanna,
Engineer, U. S. Reclamation Service.

1348 Monroe St., Washington, D. C., March 2, 1907.

Why Do Contractors Do Slipshod Work?

Sir: I cannot for the life of me see why a firm of engineers and contractors that is just starting out in business and has a reputation to make should do as I saw work being done on a new building not over a thousand miles from Bowling Green. I have watched the operations on this building from the time the old buildings were torn down, as it is on the way to the place where I get lunch. To-day I noticed a concrete gang at work. They were filling a big rectangular foundation form, and dropping the concrete about 10 ft. In the first place the form was full of water, when it should have been water-tight, I believe. The concrete was being prepared "dry." The sand and cement were being thrown into a heap and were not half mixed. Then on top of this was put dirty broken stone which was full of sticks, paper and ice, no pretense whatever having been made to insure the least bit of cleanliness. Then two shovelers got to the edge of the board and threw the stuff into the form, after it was passed to them by two other shovelers. A bluff was made at turning the mass, but I will wager that one-half the stones did not have mortar (pardon the word) on more than one-half of their surfaces. By the time the mass reached its resting place un-"mortared" stone was on the bottom and the sand and cement virtually floated on the water in the form. Thus it would go—and finally the foundation will consist of a layer of stone, then sand and cement, and so on, thus making a very stable (?) structure.

In the second place the foreman on the job was not on the job more than half of the time or he would have had sense enough to see how things were going, or else it was his positive intention to do poor work, thereby saving a few dollars for the contractors. In the third place, the concrete gang was composed of foreigners who know no more about concrete than a two-year-old child, and all they think of is to make the job last as long as possible. Now, I am sure it would have paid the contractors to have one competent conscientious man on the concrete board, for he would probably set a decent example for the rest. It took this gang three times as long to mix a batch as any other gang that I have seen, partly because the mixing board was made of wood and the gang shoveled crosswise of the planks, in this way losing in time some of the money saved (?) by improper mixing. I also noticed a couple of the laborers throwing large masses of concrete, that had evidently been put in the wrong place and had to be broken in pieces to get it out, into the form. Instead of depositing them in the center of the form, which under some specifications is permitted, they deliberately threw them into the extreme corners.

I feel sorry for the owner of this building for, if the rest of the foundation work is done in the same manner, he certainly will be stuck. I also feel sorry for the moral character of the contractors, as well as the architect of the building, who does not have an inspector on the job more than once in a while.

If it was not for the fact that I would be told to

mind my own business, I would take the trouble to find the owner and put a bug in his ear. I know this, that if ever these contractors bid on any work with which I am connected, their bid will not receive any attention.

Trusting that the contractors who read this may profit as to the opinion of an outsider, I am,

Yours truly,

A. Swartz.

c/o Erie R. R. Co., 11 Broadway, New York City, March 12, 1907.

Examination for Chief of Bureau of Water, Philadelphia

Sir: I note the editorial comment in your issue of March 7, 1907, on the examination for Chief of the Bureau of Water in Philadelphia, and beg to state that it contains some misapprehension of fact. When the board organized for the examination, it divided the work into two parts; the written, which should count 600 points and cover principally technical matters, and the oral, which should count 400 points and cover the candidate's administrative experience and ability. The examination was thrown open to the entire country, the regulation limiting appointments to Philadelphia not having then been passed.

The reason the markings appeared to be low, was because, from the importance of the position, the examination was made severe and the marking rigorous. The aim of the board was to give a full and just consideration to every point that an employer should take into account in making an appointment for his own best interests. Technical knowledge of mechanical and civil engineering; experience; ability to handle men; intelligent knowledge of work previously done, whatever its nature; age, manner, personal presence, health, and in short every qualification that had a legitimate bearing upon the question of the applicant's fitness, was given a value, and he was rigidly marked thereon. When the examination was over, the marks of each applicant in the various divisions were added together. Results were transmitted without modification to the Civil Service Commission.

Permit me to express the thought that there is no qualification of an applicant that cannot be given its full value by a proper examination, and that civil service thus conducted is far and away the most sensible and satisfactory method of selecting individuals for any kind of employment. The trouble with its application is that too often it has been limited, as you appear to have incorrectly assumed in this case, merely to book knowledge, which too often can be covered by the one qualification of a good memory.

Very truly yours, Cassius E. Gillette,
Chief Engineer, Bureau of Filtration.

Philadelphia, March 13, 1907.

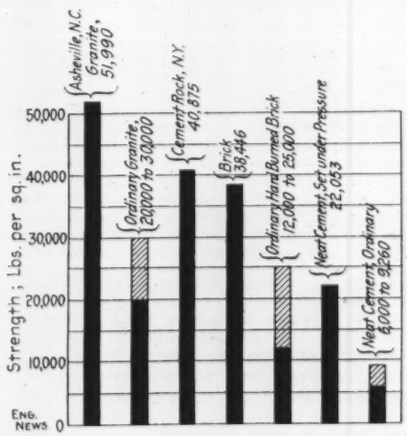
[Our comment on the examination was made with an understanding that 400 of the 1,000 points were to be covered by an oral examination, but we did not know that the oral examination was confined wholly to "administrative experience and ability." In fact, we were informed (and so stated on p. 6 of our issue of Jan. 3, 1907, in some notes introducing our reprint of the questions for the written examination), that in the oral examination civil and mechanical engineering were given 100 points each, and administrative and general, 200 points. If the latter was actually given 400 points in the oral examination then it had 600 points in all, since, if we were correctly informed, it was given 200 points in the written examination. In either case, after making a liberal allowance for whatever was covered by the vague term "general," there was still considerable weight given to experience. We are glad to know that the "examination was thrown open to the entire country." But still the questions remain: Why did only 1 of 25 candidates pass? Why did that one rank only 70.1, as against the required 70? Why did 21 of the 25 candidates fall below 50? And why was not the successful candidate appointed, if the regulation limiting appointments to Philadelphia was not then in force? These queries are not designed to throw discredit on the examining board, its questions, nor civil service examinations in general. The fact still remains that the practical outcome of this particular examination was to produce only one eligible for a $6,000-a-year position, and he, for some reason, has not received the appointment. Was it not fair, therefore, to raise a question as to the advisability of attempting to fill such a position in such a manner? Surely, the object of the examination was to secure an eligible list. To all practical purposes that object was not accomplished, and we have not heard that another examination has been ordered, although the one in question was held nearly four months ago (Dec. 4, 1906). We sought an explanation, we may add, in (1) the unwillingness of men fitted for such a position to take an examination and (2) in the local-residence qualification, which latter we supposed existed in law, as it seems to have done, eventually, in fact.—Ed.]

Notes and Queries.

Our attention has been called to the fact that on page 254 of our issue of March 7, in the article on "Lowering the Chicago River Tunnels," Mr. Samuel G. Artingstall, M. Am. Soc. C. E., was inadvertently named as "Assistant to the Chief Engineer," whereas he should have been spoken of as Chief Engineer of the work. Another error in the same connection was the statement that Mr. John (instead of James) Z. Murphy had succeeded Mr. Artingstall. Mr. Murphy is Chief Engineer of the Chicago Union Traction Co.

SOME HIGH RECORDS IN BRICK TESTS.*

At the recent meeting of the National Brick Manufacturers' Association, Lieut. J. A. Howard of Watertown Arsenal read a paper on the strength of brick in which were recorded some bricks and brick piers of unusually great strength. The strongest brick ever tested at the Arsenal was a paving brick from St. Louis, Mo., which showed a compressive strength of 38,446 lbs. per sq. in., with a modulus of elasticity of 8,510,000. The absorption was 0.21% by weight and 0.5% by volume. The sample tested was set on end and measured 2.45 × 3.09 ins. in cross section.



Some High Compressive Strength Records in Masonry Materials.

In the accompanying cut are shown some remarkable high records of other masonry specimens. The records are selected from a great number of tests made at Watertown Arsenal to show maximum records and should not be taken of course as any guide for the designing engineer.

The granite of 51,990 lbs. per sq. in. compressive strength came from a quarry in Asheville, N. C. Ordinary granites range from 20,000 to 30,000 lbs. per sq. in. The cement rock is the stone from which natural cement is made in the State of New York. The brick of 38,446 lbs. strength has just been described. Ordinary values for hard burned brick range from 12,000 to 25,000 lbs. per sq. in.

Portland cement, set under pressure, attained the maximum strength yet observed in this material. This sample was exposed to an initial pressure of 14,000 lbs. per sq. in. while setting. The strength given on the diagram was displayed by the cement at the age of 57 days. The compressed strength of ordinary Portland cement, tested neat, ranges from 6,000 to 9,260 lbs. per sq. in.

*Reprinted from Engineering News of March 14, 1907, on account of omission of cut.

REPORT ON THE POLLUTION OF THE WATER SUPPLY OF PHILADELPHIA BY COAL WASTES.

A commission to investigate the pollution of the water supply of Philadelphia, particularly pollution by coal dust, was appointed in December, 1905, by Mr. John Weaver, Mayor of the city. The commission originally consisted of the following: Dr. W. M. L. Coplin, Director of the Department of Public Health and Charities; Mr. George S. Webster, Chief Engineer of the Bureau of Surveys, and Mr. Frank L. Hand, Chief of the Bureau of Water. Mr. Hand subsequently resigning, his place was filled by Major Cassius E. Gillette, Chief Engineer of the Bureau of Filtration. In a preliminary report made by the Commission in March, 1906, the sources of sewage pollution within the city were dealt with and an additional trunk sewer was recommended, together with compulsory house connections with existing sewers. On Feb. 14, 1907, the Commission submitted a second report. This report deals chiefly with coal waste pollution, but it also contains some detailed recommendations regarding the prevention of sewage pollution within the city limits.

The Commission states in its report that it has visited coal breakers and washeries in both the Schuylkill and Delaware drainage areas, and has found that each river is being seriously polluted by the washings from coal passing through the breakers and by washing from heaps of coal waste. In some instances, mining companies were effecting a thorough clarification of wash water by means of sedimentation basins in which the coal dust was intercepted. Water from some of the coal breakers and washeries was found to contain as many as 63,162 parts per 1,000,000 of suspended matter, whereas the settled water contained only 112 parts. Table I. shows the amount of suspended matter from mine water and from washery water, the latter with and without sedimentation. Tables II., III. and IV. give the results of chemical and bacterial analyses of water collected from the Schuylkill River at various points.

An official opinion rendered by the City Solicitor states that "the present law is adequate to prevent the pollution of the streams contributing to the water supply of the city by coal waste." In order to secure convictions it would be necessary for the city to employ at least three inspectors to patrol the portions of the drainage areas located in the coal mining districts. As to the abatement of sewage pollution, the Commission states that ample authority to this end is now vested in the State Department of Health, and that it is understood that the matter will receive attention from that department. The Commission renews its recommendation of March 5, 1906, to the effect that the city appropriate $200,000 for the construction of sewers in Manayunk and other points on the east bank of the Schuylkill River and also in the Wissahickon drainage area, in order to protect those streams. It also recommends that $40,000 be appropriated to the Department of Public Health to enable it to compel houses to be connected with the sewers, and that $7,000 a year be made available for the inspection of coal breakers and washeries.

Appended to the report of the Commission is a special report on coal dirt pollution, by Messrs. Fairchild and Gilchrist, Civil and Mining Engineers, dated Sept. 8, 1906. This report is printed below in full, with the exception of statements relating to the various collieries in the

TABLE I.—SUSPENDED MATTER—SOLIDS IN PARTS PER MILLION.

Source.	Water discharged from mine.	Water discharged from washery.	Water discharged into stream.—No effort at sedimentation.	Water discharged into stream.—From sedimentation basins after percolation through banks.
Wadesville Colliery.....	64	63,162	50,617	112
Eagle Hill Colliery.....	32	11,849	.....	48
Silver Creek Colliery.....	36	16,327	.....	
Lehigh C. & N. Co. Shafts 10, 12, 15.....	139	14,870	.....	52

Schuylkill and Delaware basins. These statements give the yearly output of each colliery, the provisions, if any, for excluding coal from the rivers. The report is as follows:

GENERAL CAUSES OF POLLUTION.—We find that the anthracite coal industry is now depositing, and for the past has been depositing, large quantities of coal in portions of the upper watersheds of the Schuylkill and Delaware Rivers. Owing to its low specific gravity and fine state of division, this coal dirt is easily carried far down stream by running water, and is frequently found in the lower portions of the valleys of the rivers.

In the ordinary low stages of the rivers no portion of the coal dirt entering the streams finds its way more than 20 or 30 miles. In that distance all of the suspended coal dirt is sooner or later dropped upon the bottom, where it goes to build up the bed of the stream, which actually flows over a foundation of coal dirt. In the freshets, however torrents, coming directly from many of the collieries, no coal dirt settles, but on reaching those portions of the where the velocity is checked, as in dams and quiet reaches, settlement takes place, the result being that inequalities in grade are eliminated and the stream meanders over broad beds of coal dirt. In the Schuylkill basin these stream deposits attain their greatest development in the vicinity of Auburn and Schuylkill Haven. In the Delaware basin they are well developed in the desolate Beaver Meadow.

But the upper watersheds of these rivers is not the final resting place of this coal dirt, as every resident of the City of Philadelphia well knows. In times of high water vast quantities of it are carried down stream, and, indeed, in the case of a river like the Schuylkill, all sediments entering it must ultimately reach tidewater; for even those deposits that are not moved by the yearly floods must eventually go when the barriers that retain them are eroded or carried away.

In addition to the coal dirt washed directly into the streams at all times, there is a large amount of slightly coarser stuff that is deposited upon the dumps. In times of heavy rains this is gullied and washed down into the streams.

As far as the City of Philadelphia is concerned, our investigation thus pertains to the menace of the pollution of our rivers by the coal dirt at all times existing in the upper watersheds:

First, the coal dirt that is daily washed into the streams, and,

Second, the coal dirt existing on the dumps.

COAL DIRT DAILY WASHED INTO THE STREAMS.—All anthracite coal, on coming from the mine, is run through a breaker, where it is crushed, sized and washed.

In addition to the mine output, much coal is now won from the old piles of coal dirt that in former years was considered worthless. The coal from these old banks is reclaimed by slushing with a jet of water and transporting it by endless conveyors to the screens in the breaker building. The term "breaker" does not strictly apply to this building, where the material is not crushed, but the processes are the same in all other respects. Where this is done exclusively the plant is termed a "washery," but in our present purpose it is immaterial whether the plant is a washery or an ordinary "wet" breaker, for in either case the coal is washed by water and the discharge is equally black.

Many of the large coal companies are now washing the old banks in addition to the regular mining operations. There are a few coal breakers, known as "dry" breakers, that handle the coal dry. Out of some 46 breakers we only noted 3 dry ones, they being Nos. 4, 8 and 9 of the Lehigh Coal and Navigation Company.

Waters pumped from the mines and emptied directly into the streams are practically free from coal dirt. Water used in the breakers is derived from the streams or from the mine, or both, but its source is immaterial in the present investigation. The black and heavily charged water discharging from the breakers into the creeks is the only daily or dry weather source of pollution by coal dirt. The actual amount of sediment contained in a cubic foot of discharge varies greatly. A sample taken at Hazleton shaft breaker showed 2.64 lbs. of solid per cu. ft. of water, and another, taken at Upper Lehigh No. 2, showed .95 lb. While these discharges appeared equally black, still the heavier one contained larger particles in addition to the fine mud. The figures are the result of dry weighing.

We have reason to believe that the figure obtained from the Upper Lehigh colliery represents more closely than the other the general average throughout the coal fields. On Aug. 28 this colliery was discharging 138 cu. ft. per min. In 1904 it shipped 236,000 tons of coal. From this we estimate that some 90 lbs. of coal dirt passed out in the wash water for every ton of coal shipped. This represents a waste of 4½% through the wash water alone.

The figures just given must be looked upon as highly approximate. All the quantities from which they are calculated are subject to great variation. The colliery selected is one that seemed to present normal conditions. Using the figures obtained from it, we arrive at the following:

FIGURES APPLYING TO ALL COAL OPERATIONS IN THE SCHUYLKILL AND DELAWARE BASINS.

.95	lbs. of coal dirt per cu. ft. of water.
94.6	cu. ft. of wash water per ton of coal shipped.
89.9	lbs. of coal dirt per ton of coal shipped.
5,809,000	tons of coal shipped in 1904.
261,405	tons of coal dirt washed into stream in 1904.
193,633	cu. yds. of dirt washed into stream in 1904.
193,633	cu. yds. is equivalent to a cube 173 ft. on a side.
193,633	cu. yds. would cover a stream bed 50 ft. wide and 1 ft. deep for 20 miles.
7,500	sq. mi.—Area of Delaware watershed above Philadelphia.
1,800	sq. mi.—Area of Schuylkill watershed above Philadelphia.
4.17	Ratio of above watersheds.
15.4	sq. mi.—Area of Delaware coal fields.
109.7	sq. mi.—Area of Schuylkill coal fields.
1,835,000	tons shipped from Delaware fields in 1904.
3,974,000	tons shipped from Schuylkill fields in 1904.
244	tons shipped in 1904 per sq. mi. of watershed, Delaware basin.
2,208	tons shipped in 1904 per sq. mi. of watershed, Schuylkill basin.

The last two figures are pertinent as showing, in a measure, the relative average degree of pollution of the two rivers at Philadelphia; that is, a cubic foot of Schuylkill water will average about ten times as much coal dirt as a cubic foot of Delaware water. It may be argued that the greater length to be traveled in the case of the Delaware should still more increase this proportion, but we are inclined to think that this would only decrease the size of the particles and not affect its total amount.

You will notice that, considering the size of the coal areas, much less is mined per acre in the Schuylkill basin than in the Delaware. This is significant as indicating that mining operations will become more vigorous in the Schuylkill basin in the future when the other fields become relatively exhausted.

COAL DIRT PILED IN THE VICINITY OF STREAMS.—Throughout the anthracite coal fields are numerous and enormous piles of waste material or culm. A large part of this is black slate, and another large part is fine coal or coal dirt that is at present not marketable. One is struck by the huge dimensions many of these banks have attained. The more thoughtful are also struck by the fact that these piles represent a tremendous amount of potential energy that is discarded at present only because better material is so near at hand under ground.

These piles, when composed of coal dirt, are especially likely to be gullied and washed in part into the streams in times of heavy rains. Attempts are sometimes made to prevent this by constructing a dry wall or a cribwork of logs at the top of the pile.

At some of the breakers the black water is passed through a bin or settling box, in order to free it from at least the coarser part of its charge. From this box the wet material is taken to the dump, where, if badly placed, it is likely to be washed into the streams. Thus, in addition to the older piles of coal dirt, we have this newer fine material which is being deposited daily at many of the collieries and constitutes an ever-increasing menace to the purity of the streams.

PRECAUTIONS TO PREVENT POLLUTION.—All the collieries of the Lehigh Coal and Navigation Company on the Schuylkill side are now using relatively successful means to prevent the daily dry weather pollution of the streams by coal dirt.

The culm banks (more especially the slate) are disposed in such a way that basins are formed along the side or at the head of a valley. The dirty water is pumped into these basins, where all the dirt settles. The water filters through the slate and all that enters the stream is perfectly clear.

The culm banks are kept from 10 to 40 ft. higher than the water level, which is maintained for the most part only slightly above the deposits on the bottom. The position and amount of the escaping water, as well as its level, is controlled by a 4 or 5-ft. layer of clay gravel on the inside.

The location and size of the retaining banks about these basins render them free from liability to washout. The superabundance of slate should render their enlargement inexpensive, since the slate piles rise faster than the mud collects. New basins could be established by using some existing culm pile, as far as possible, and directing the future output of slate and rock to complete and continually maintain or build up the enclosure.

Many of the collieries in the basin of the Schuylkill proper are making much less effective attempts to retain the coal dirt. Enclosures are built entirely of coal dirt, the banks being kept about 3 ft. higher than the water level by continual excavation of the mud from within. There is, strictly speaking, no water level at all, since the interior is a sloping, fan-shaped delta over which the water runs, the escape being through the dirt pile by means of gate boxes. In nine cases out of ten the water coming from these enclosures is very black. Not only are the outside slopes likely to gully, but they sometimes give way altogether, allowing much of the interior to flow out, as was the case at Eagle Hill.

We believe that retention basins like those used by the Lehigh Coal and Navigation Company are effective in eliminating all pollution by dirt from the breakers. An inspector or stream warden should watch the discharges, and no "emergency" overflow should be allowed.

Very few dams, thrown directly across a stream of any size, are in use as retention basins for coal dirt. Evidently such dams get all the brunt of a flood, while basins located on the side hills are relatively immune.

None of the collieries draining into the Delaware River system make any systematic attempt to purify their black discharges.

Very little seems to have been done anywhere to pre-

TABLE II.—RESULTS OF CHEMICAL ANALYSES OF SAMPLES OF WATER FROM THE SCHUYLKILL RIVER, COLLECTED ABOVE AND BELOW READING, NORRISTOWN AND MANAYUNK.

(November 14, 1906.)

Source.	Turbidity.	Total solids.	Total organic ammonium nitrogen.	Nitrogen as nitrites.	Nitrogen as nitrates.	Oxygen consumed.	Chlorine.	Iron.	Sulphuric acid, SO_3.	Alkalinity.	Total hardness.
10-25-06: Above Reading	2	118	.18	.002	.72	.80	2.4	.18	44	15	86
10-25-06: Below Reading	18	134	.30	.005	.84	1.55	3.0	.80	31	38	100
11-1-06: Above Norristown	9	114	.27	.004	.76	1.70	3.6	.50	26	33	91
11-1-06: Below Norristown	21	125	.43	.007	.75	2.50	4.4	.68	26	36	91
11-8-06: Above Manayunk	22	139	.42	.007	1.17	2.25	5.0	1.16	34	40	108
11-8-06: Below Manayunk	13	140	.42	.008	1.23	2.20	5.7	.80	33	42	111

TABLE III.—RESULTS OF BACTERIOLOGICAL EXAMINATIONS AND SAMPLES OF WATER FROM THE SCHUYLKILL RIVER COLLECTED BELOW READING, ABOVE AND BELOW NORRISTOWN, AND ABOVE AND BELOW MANAYUNK.

(November, 1906.)

Source.	Bacteria. Date.	Per c. c.	Date.	Per c. c.	Date.	Per c. c.	Date.	Per c. c.	Date.	Per c. c.	Date.	Per c. c.	Date.	Per c. c.
Below Reading	20	2,000	21	2,400	22	5,200	23	850	26	130,000	27	290,000	28	97,000
Above Norristown	20	60,000	21	58,000	22	48,000	23	27,000	26	20,000	27	13,000	28	7,500
Below Norristown, abt ½ mile below the lower sewer	20	93,000	21	80,000	22	260,000	23	51,000	26	66,000	27	130,000	28	170,000
Above Manayunk, regular samples, Float at Shawmont	20	170,000*	21	320,000	22	150,000	23	84,000	26	30,000	27	24,000	28	14,000
Below Manayunk, Wharf at Riverside Mansion	20	230,000	21	280,000	22	200,000	23	120,000	26	39,000	27	28,000	28	26,000

*Spigot at Shawmont. Samples, collected below Reading on November 20th, (21st, 22d and 23d were from the west side and the remaining three from the east side of the river, about ½ mile below the sewer.)

Approved, George Edward Thomas, Chemist.

TABLE IV.—REPORT OF BACTERIOLOGICAL EXAMINATIONS OF SAMPLES OF WATER FOR BACTERIA RESEMBLING B. COLI COMMUNIS. COLLECTED BELOW READING, ABOVE AND BELOW NORRISTOWN, AND ABOVE AND BELOW MANAYUNK.

(November, 1906.)

Source.	Bacteria Per Cubic Centimeter. B Coli Com. Date.	B Coli Com.	Date.	B Coli Com.	Date.	B Coli Com.	Date.	B Coli Com.	Date.	B Coli Com.	Date.	B Coli Com.	Date.	B Coli Com.
Below Reading	20	4	21	3	22	3	23	0	26	300	27	500	28	200
Above Norristown	20	160	21	20	22	150	23	0	26	2	27	17	28	10
Below Norristown, about ½ mile below the lower sewer	20	240	21	400	22	170	23	160	26	100	27	200	28	130
*Above Manayunk, regular sample	20	400†	21	120	22	67	23	80	26	10	27	2	28	3
Below Manayunk, Wharf at Riverside Mansion	20	400	21	130	22	67	23	150	26	170	27	83	28	200

*Spigot at Shawmont.
†Float at Shawmont.

Approved, George Edward Thomas, Chemist.

vent the wash from the existing piles of coal dirt. In most cases the angle of slope might be reduced and more effective cribs or walls built at the bottom. Anything that would encourage the growth of vegetation on the surface of the pile would be good. A small amount of earth added to the surface might do this. All this, of course, presupposes that the present production of the exposed piles of loose material is to stop.

Supposing that the pollution from the two general sources already described were to discontinue, there would still be the large amount of dirt already resting on the flood plains and on the bottoms of the upper river courses. Ultimately this might all be carried out to sea, but for many years it would continue to be a nuisance to the lower cities in time of flood.

A systematic dredging of the streams will clean the river and eliminate the menace to a large degree. Such an operation may pay. Small concerns are now dredging the Schuylkill at Auburn and at Port Clinton and marketing the product.

We are indebted to Mr. George S. Webster, Secretary of the Commission, for a portion of the Journal of the Select Council of Philadelphia containing the report from which the above extracts have been taken.

FIRE AND LOAD TEST OF A REINFORCED CONCRETE BEAM.

By H. B. MACFARLAND.*

The record of information to be found in various engineering publications, and especially the record of the notable tests made by Prof. A. N. Talbot of the University of Illinois more than two years ago, establishes to a satisfactory degree the principles governing the action and strength of reinforced concrete beams. At the present time, however, one finds that reinforced concrete beams and columns unprotected by fireproofing material are used in supporting heavy loads in warehouses, factories and office buildings. No experiments have ever been made in a practical manner to establish the principles that govern the action and strength of reinforced concrete beams under both *load and fire*, which is liable to occur in a warehouse for a period of time. In August, 1906, the writer conducted a fire test showing that reinforced-concrete columns lose 70% of their strength and elasticity if exposed to a temperature of 1,600° F. for a period of two hours. [Published in Engineering News of Sept. 20, 1906, p. 316.] Arrangements

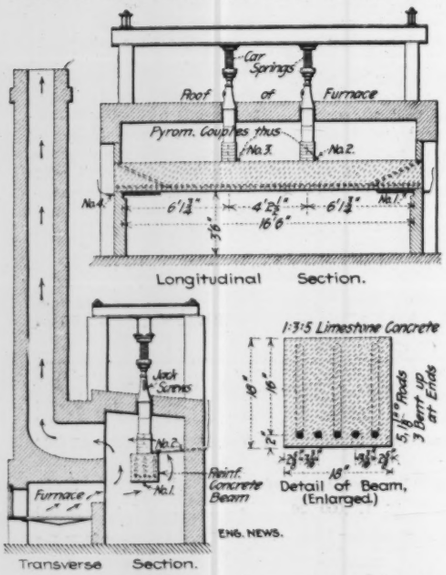


Fig. 1. Arrangement of Furnace and Test Beam for Fire Test of Reinforced Concrete Beam.

were made at that time to conduct a fire and load test on a concrete beam. The details of this latter experiment are herein given.

This experiment was conducted by the writer at the experimental laboratory of the National Fire Proofing Co., Chicago, at the request of Mr. E. V. Johnson, Vice-President and Western Manager of that company. An excellent opportunity for a test of this kind was afforded from the fact that the furnace was designed to take beams of good size and long span, and to subject the beams to a load while in the furnace.

The object of the test was to investigate the action of a full-sized reinforced concrete beam, carrying a safe load, when placed in a furnace and exposed to a temperature of about 1,800° F. for a period of three hours, and at the same time to determine its fireproof qualities.

The beam was made on Nov. 1, 1906, in the testing laboratory. The concrete consisted of 1 part Atlas cement, 3 parts torpedo sand, and 5 parts ¾-in. limestone. The sand and stone were first thrown together and turned over four times; the cement was added and all turned over three times; water was supplied from a hose and the mixture turned over twice. The bottom of the form was covered 1½ ins. deep with concrete, the plain reinforcement rods were then laid on it and the form was filled to its top with concrete, ordinary care being taken to tamp it into place until water came to the top. Neat cement made a smooth finish on the outside. As soon as the cement had set, the sides and ends of the form were taken off. A fire was kept in the room and the temperature was never below freezing.

The beam, shown in Fig. 1, was 18 × 18 ins., and 17 ft. 4½ ins. long., area of cross-section 324 sq. in.; volume 39.1 cu. ft.; weight 5,865 lbs. The reinforcement consisted of five mild steel plain rods 1¼ ins. diameter, extending the full length of the beam; the rods were equally spaced across the beam 3⁷/₁₆ ins. c. to c., were 16 ins. from the top and 2 ins. from the bottom of the beam, and the ends of the center and two outside rods were turned up diagonally as shown. The cross-sectional area of the rods was 4.97 sq. ins., equal to 1.73% of the cross-sectional area of the beam above the reinforcement rods.

On Feb. 8, 1907, the beam was placed in the furnace as shown in Fig. 1. Tile walls were built to support the ends of the beam, and these walls also served to form the curtain wall of the ends of the furnace. Two piers of fire brick were built upon the beam, 4 ft. 2½ ins. c. to c. and equidistant from the end; these extended through the roof of the furnace and the load was applied on top of them by means of jack-screws which compressed 5-ton standard M. C. B. car springs, as shown. Special cap castings were made to be placed on the ends of the springs. The springs were calibrated in a hydraulic compression machine. With no load, the distance between the caps in which the ends of the springs fitted was 16 ins.; with a load of 2½ tons, the distance was 12 ins. Both springs gave the same readings. The jack-screws had a pitch of ½-in., so that one turn of the jack-screw represented a change of 715 lbs. in the load.

The test was made Feb. 13, 1907, from 3 to 6 p. m., under most favorable weather conditions. The beam at this time was 104 days old. The springs having previously been calibrated were put in place and jack-screws screwed up until the load on each spring was 2½ tons. During the test the jack-screws were kept turned up so that the distance between the caps was always 12½ ins. One turn of the screw changed the pressure by 715 lbs., and as it was easy to keep the pressure regulated so that the angular measurement was estimated within 15°, there was only about 1% variation in the load. At periodic intervals readings were taken of the number of turns of the jack-screw levers, and the deflection of the beam was calculated in inches.

The furnace was heated by means of wood as fuel. There are four fireboxes in which the wood is burned, and the construction of the furnace is such that it makes an exceptionally even distribution of the heat. The fires were started at 3.10 p. m. and the temperature of the furnace was measured at four places by means of a Bristol electric pyrometer with four couples. These couples were placed as shown in Fig. 1: No. 1 at the east end and under the beam; No. 2 at the east load pier and on top of the beam; No. 3 at the west load pier and on top of the beam; No. 4 at the west end and under the beam.

Temperature readings were taken every minutes; the observations have been plotte an average temperature curve drawn, as s in Fig. 2. The same figure shows graphicall deflection of the beam during the period o test. At 3.25 the maximum temperature was 700° F. and the beam showed a deflecti 1/16-in. One hour after the fire was starte temperature averaged 1,500° F. and the deflection of the beam was 1¼ ins. under load point. The beam continued to deflect

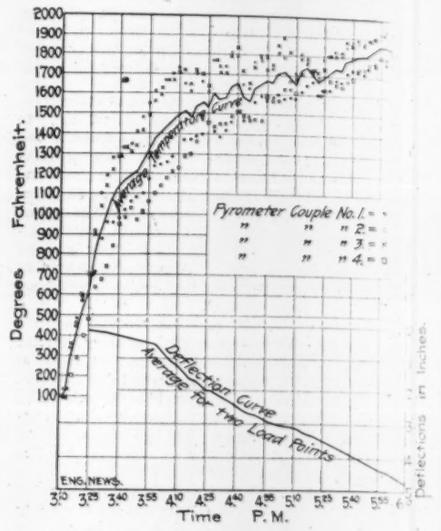


Fig. 2. Diagram of Temperatures and Deflections Measured During Fire Test of Reinforced Concrete Beam.

rather uniform manner until the end of the test when the total deflection was 4¾ ins. At 6.10 p. m. the furnace fires were drawn and the furnace closed, the loads remaining on the beam. The next morning the distance between the caps on the springs was 15⅝ ins., showing that the beam had continued to deflect under its own weight and the decreased tension in the spring due to the deflection of the beam.

An examination of the beam after the furnace was opened showed that the concrete had fallen off the beam in large pieces, exposing the steel rods, and that the maximum deflection of the beam at its center was 8⁹/₁₆ ins.

A NOVEL USE OF THE TELEPHONE IN SURVEYING.

At a recent meeting of one of the State Engineering Societies, a member related a novel use of the telephone in surveying. The owners of some oyster beds were greatly annoyed by poachers who came in flocks of four and five boats and dredged the oysters from the beds. There was no police system in the place and the only redress was a criminal prosecution under warrant.

Particular difficulty was experienced in getting evidence as to the exact position of the boats at the time of their dredging operations, such evidence being called for by the courts before they would issue a warrant. An engineer was called in to locate the boats. He first started to plot a time-position path of the boats, obtaining his data by the method of double instrument transit readings ordinarily used in plotting soundings. This was found impossible as the notes of the two transitmen, whose positions were some 1,500 ft. apart, were greatly confused owing to the difficulty in each man sighting on the same boat at the same time. There were always four or five boats moving around the beds at once.

The engineer then rigged up a telephone system equipped with 1,500 ft. of insulated wire laid along the ground between the transit stations, two batteries of dry cells and two headpiece transmitter and receiver devices such as the central operator in a telephone station wears. This had the advantage over heliographing or signaling that the transitmen did not have to

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watch the other man, but was enabled to carry on his notes and observations and a conversation with the other man at the same time. As each boat had on it a license number plainly visible through the instrument, it was very easy for the two men to take simultaneous readings on the same boat. The curves were readily plotted from this last set of notes and the poachers convicted.

PROPOSED NEW BRIDGES OVER THE MISSISSIPPI RIVER AT ST. LOUIS, MO.

Considerable interest attaches at the present time to the projects for new bridges over the Mississippi River at St. Louis, and it seems likely that two of these will be carried into effect. At present there is only one bridge for highway traffic, that being the Eads Bridge, which also carries a double-track railway on the lower deck. There has been recently considerable agitation for another highway bridge, and this project is popularized by the proposal to make it a free bridge, tolls having to be paid on the Eads Bridge. A four-track railway bridge to relieve the traffic congestion is also proposed, and a bridge for an electric interurban railway has been authorized by Congress. The present and proposed bridges are shown on the accompanying map, and some particulars of these are given below.

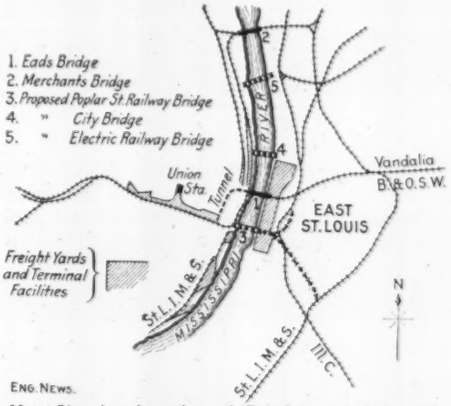
1. THE EADS BRIDGE.—This bridge, which directly connects the cities of St. Louis, Mo., and East St. Louis, Ill., is the famous bridge which was designed and built by the late James B. Eads; it was commenced in 1867, and opened to traffic in 1874. It has three steel arch spans, the center one 515 ft. and the others 497 ft. in the clear, with a headway of 56 ft. At each end is a masonry viaduct approach with five 26-ft. arches, the total length of the bridge being 1,628 ft. On the upper deck is a roadway, with two sidewalks, and the tracks for the electric cars are placed next to the sidewalks.

The eastern approach to the roadway is inconvenient, having a grade of 4%. Beneath the roadway are two tracks, which at the St. Louis end of the bridge enter a tunnel about 4,095 ft. long, leading under the city towards the union station. The tunnel is in two portions, at right angles to each other, and is so fouled by smoke and gases as to be extremely uncomfortable and even dangerous for passengers, while with the sharp curve and a 1½% grade against eastbound trains it serves to check and throttle the movement of traffic. Attempts to improve the conditions by ventilation have been made, but without success, and nearly all passenger trains are now run by way of the Merchants Bridge in order to avoid the tunnel approach to the Eads Bridge. In a report made last year, by the engineers to the Municipal Bridge & Terminals Commission, it is stated that the minimum time allowed for a train to pass through the tunnel is four minutes, and for reasons of safety no train is allowed to enter until the preceding one has passed out. Thus at the busy hours only 15 trains in an hour could pass the bridge and tunnel.

2. THE MERCHANTS BRIDGE.—This was built in 1889-90 by an independent concern to break the railway monopoly on the Eads Bridge, but it is now controlled and operated by the same interests which own and operate the latter. An unsuccessful attempt to take it out of the hands of these interests was made a few years ago. The late George S. Morison, M. Am. Soc. C. E., was Consulting Engineer. The bridge is some miles above the city, and would be of no use for highway traffic. It is a double-track structure with three through truss spans of 500 ft. in the clear (523 ft. 6 ins. c. to c. for the central span, and 521 ft. 6 ins. for the two side spans). The total length of bridge and approaches is 13,760 ft. The clear headway under the channel span is 50 ft. At the east end lines have been built connecting with the numerous railways. On the west side the line swings round and runs south near the bank of the river, partly on the street level and partly on the steel viaduct along the levee toward the union station.

3. THE PROPOSED POPLAR ST. BRIDGE.—In spite of the two existing railway bridges there is great congestion of traffic at St. Louis, both in regard to passenger and freight service. The objections to the Eads Bridge for railway purposes have already been noted, while for trains of the railways from the south (the Illinois Central Ry., St. Louis, Iron Mountain & Southern Ry., Vandalia Line and Baltimore & Ohio Southwester Ry.) to run up the east side to the Merchants Bridge and then back to the St. Louis terminal station means an extra six or ten miles for the different roads. In 1905, the Mayor and Municipal Assembly appointed a Municipal Bridge and Terminals Commission to consider the question of improved bridge and terminal facilities, and this commission appointed Messrs. Robert Moore, M. Am. Soc. C. E., and Albert T. Perkins, of St. Louis, as its consulting engineers.

The plan proposed by the engineers was to build a new bridge almost in a line with Poplar St., with elevated approaches and with connecting lines to serve the various railways on the east side of the river. This would give a direct lead into the terminal yards of the union station, these yards lying in an east and west direction, while the station itself stands at the end of a Y to the north of the yards. Under the proposed arrangement the Eads Bridge would then be abandoned for railway purposes, and it was suggested that the tunnel should then be utilized as a part of the proposed street railway subway, the electric cars (local and interurban) crossing



Map Showing Location of Existing and Proposed Bridges at St. Louis, Mo.

the bridge on the lower deck and thus leaving the entire roadway clear for vehicle traffic.

The bridge itself, as designed by Mr. Moore, was to have a cantilever span of 1,600 ft. c. to c. of piers, with anchor arms of 450 ft. The width between trusses was 75 ft. c. to c. at the piers, and 56 ft. at the center. The approach viaducts were about 50 ft. wide on the floor with columns spaced about 33 ft. or 36 ft. c. to c.; the outer tracks would be directly over the columns, and the inner tracks between the columns. The maximum grade of the approaches on both sides would be 1.07% as compared with 1.50% on both approaches of the Eads Bridge. No attempt was made to adapt the Poplar St. bridge for highway traffic, as it is so far out of the line of such traffic as to be unsuitable, while it would require heavy approach inclines. The cost of this structure was estimated at $8,000,000, including land, approaches, tracks, signal equipment, etc., complete and ready for operation; of this amount the 1,600-ft. cantilever span represents $4,520,000.

4. THE CITY FREE BRIDGE.—A project now being put forward by the city is to build a bridge of its own, over which no tolls would be charged. This is popularly known as the "free bridge" project. The bridge would have a double track railway, a roadway with tracks for electric cars, and two sidewalks. No plans have yet been made, and the project is as yet in a very indefinite state. Numerous locations have been suggested, but some of these are objectionable for engineering reasons, or as being out of the lines of traffic between the cities. In this latter respect the Eads Bridge possesses special advantages, as it affords a direct line of communication between the business centers on either side, and the removal of the electric cars to the lower deck (as suggested by Mr. Moore) would of course greatly increase the traffic capacity of the roadway. The matter of the new city bridge is now in the hands of a special committee composed of three members of the City Council and three members of the House of Delegates, with Mr. Julius Lesser (Councilman), as chairman. This committee has in charge the selection of a site for the bridge and the presentation of plans for the approval of the War Department; it has been at work for about three months, assisted by Mr. Mitchell, U. S. Government Engineer, and Mr. A. T. Perkins, the city's terminal expert. Mr. Henry Rohwer and Mr. Carl Gayler, Mems. Am. Soc. C. E., have now been appointed by the committee to assist it in selecting the site of the bridge and to prepare the necessary plans. The city has voted to issue bonds for $3,000,000 for the cost of the bridge, although this amount would of course be insufficient to provide for the land, approaches and terminal facilities. At present, however, the constitutionality of the bonds is before a court.

5. THE ELECTRIC RAILWAY BRIDGE.—The Illinois Traction System, which owns about 500 miles of interurban electric railways in Illinois and which is building various new lines, now reaches East St. Louis and is running sleeping cars into that city, as noted in our issue of Jan. 17. It has long contemplated an entrance to St. Louis, but the existing facilities do not offer favorable opportunities. The interests at the back of the interurban system, known as the McKinley syndicate, have therefore decided upon the construction of a bridge for their own purposes, and have obtained the necessary authority from Congress. The bridge will be below the Merchants Bridge, crossing from Venice to a point in the northen end of St. Louis. No official information as to the structure is available, but it is stated that the bridge, exclusive of its connections and terminals, will cost about $1,000,000.

COMPARATIVE COST OF COOKING BY ELECTRIC HEAT AND BY FUELS.

A series of experiments in electrical heating and cooking have been carried out in the Home Economics laboratory of the Thomas S. Clarkson Memorial School of Technology, by Miss Charlotte D. Seaver. Although Prof. John P. Jackson, of Pennsylvania State College, some years ago made investigations as to cost of cooking by electricity,* he did not measure or weigh the foods cooked and took no account of the time required for getting the temperature up to that required for effective cooking; while comparisons of relative costs were made only with coal. Miss Seaver's experiments, however, covered all these points, comparisons being made with coal, gas, gasoline and kerosene ranges, while several different makes of cooking apparatus were used. Her investigations were made by first cooking certain specific articles of food and then complete meals, consisting of a breakfast, luncheon and dinner. She summarizes the results of her experiments as follows:

> At the rate of four cents per kilowatt-hour, cooking by electricity would cost double that done by gas fuel; and, at the prices ordinarily paid for electricity it would cost at least six times that of gas or coal, which are the fuels most commonly used. This fact, together with the initial cost of the apparatus required, would appear to forestall its general adoption at present.

The comparative cost of cooking with various fuels, for the same kind and character of cooking operation, the time in each case being based on one hour, is given in the table below.

*The Economy and Utility of Electrical Cooking Apparatus, Transactions, American Institute of Electrical Engineers, Vol. XIV., p. 481.

Source of heat for cooking.	Electricity	Coal.	Gas.	Gasoline.	Kerosene.
Amount of energy or fuel required for given cooking operation	1.032 kw-hr.	10.5 lb.	20 cu. ft.	0.0832 gal.	0.078 gal.
Cost (assumed)	$0.04 per kw-hr.	$7.00 per ton	$1.00 per 1,000 cu. ft.	$0.15 per gal.	$0.14 per gal.
Cost of cooking by given source	$0.0413	$0.0367	$0.02	$0.0124	$0.0109

THE EFFECT OF EXTREME TEMPERATURES ON THE RECOVERY OF STEEL FROM OVERSTRAIN.

It seems to be well established that at medium temperatures the elastic limit of steel subjected to a moderate overstrain will first drop below the normal, but after a lapse of time will return to the same or possibly a higher point. If this overstrained metal is placed in an extremely high or low temperature, the effect on the elastic qualities is rather uncertain. In order to gather some data on these subjects experiments have been made in the laboratories of the College of Civil Engineering, Cornell University, the results of which were given in a paper by Prof. E. J. McCaustland, of that college, before the American Institute of Mining Engineers at its London meeting, July, 1906, and reprinted in the Transactions of the Institute.

The four following investigations were carried on:

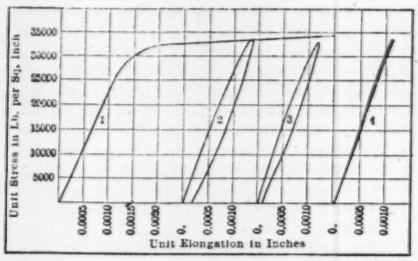
(1) The effect of time on the recovery of steel from overstrain; temperature about 60°-70° F.

(2) The accelerating effect of high temperature (steam bath) on the time of recovery of steel from overstrain.

(3) The retarding effect of low temperatures (between 20° and 30° F.) on the time of recovery of steel from overstrain.

(4) The effect of high and also moderate temperatures on overstrained steel which has been subjected for a considerable period to a low temperature.

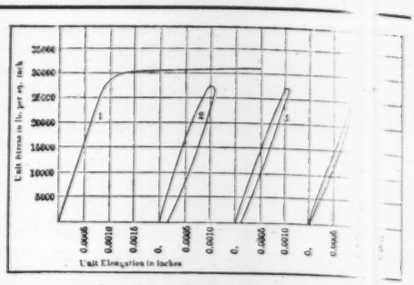
The steel used in the tests was of two kinds. The first was an extra soft steel with an elastic limit around 28,000 lbs. per sq. in., the specimen being cut from a ⅝-in. plate and milled to a 2-in. width. The second was of mild steel, with an elastic limit about 30,000 lbs. per sq. in. in ⅝-in. rounds, giving a sectional area of 0.312 sq. ins. The tests seem to show that recovery is more gradual as the carbon increases in the metal, but as this difference has no bearing on the subject at hand no distinction is made between the two kinds of material as far as the deductions are concerned.



Specimen 1, Extra Soft Steel.

Section, ⅝-in. by 2 ins. Area, 1.25 sq. ins. Elastic limit, 27,500 lbs. per sq. in. Permanent set in 8 ins., 0.04-in.

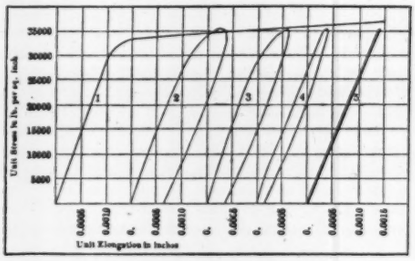
1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 19 h. after overstrain.
4. 68 h. after overstrain.



Specimen 2, Extra Soft Steel.

Section, ⅝-in. by 2 ins. Area, 1.25 sq. ins. Elastic limit, 28,000 lbs. per sq. in. Permanent set in 8 ins., 0.03-in.

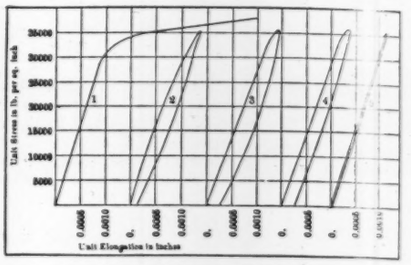
1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 18 h. after overstrain.
4. 69 h. after overstrain.



Specimen 3, Mild Steel.

Round rod, 0.63-in. diameter. Area, 0.312-sq. in. Elastic limit, 32,000 lbs. per sq. in. Permanent set in 8 ins., 0.06-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 25 h. after overstrain.
4. 48 h. after overstrain.



Specimen 4, Mild Steel.

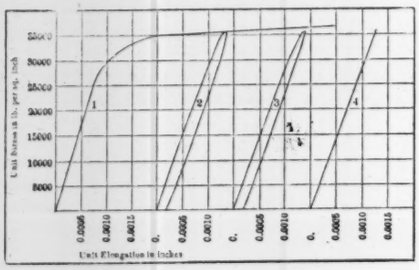
Round rod, 0.63-in. diameter. Area, 0.312-sq. in. Elastic limit, 32,000 lbs. per sq. in. Permanent set in 8 ins., 0.04-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 23 h. after overstrain.
4. 47 h. after overstrain.
5. 359 h. after overstrain.

FIG. 1. SHOWING THE EFFECT OF TIME ON THE RECOVERY OF STEEL FROM OVERSTRAIN AT MODERATE TEMPERATURES.

The tests were made on pieces of 8-in. gage length, readings being taken with an electrical contact micrometer, reading to 0.001-in. and by estimation to 0.0001-in. Prof. McCaustland describes the method of taking tests as follows:

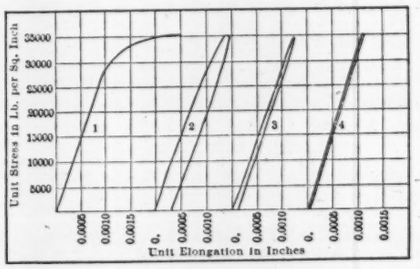
> To determine the stress-deformation relations, loads were applied, increasing by equal increments, and the micrometers were read at each loading, to determine the elongations. The load was occasionally reduced to zero, and the micrometers were read in order to determine the amount, if any, of the permanent elongation of the piece. In the accompanying diagrams, the loads are reduced to lbs. per sq. in.; and the elongations determined from the micrometer-readings are reduced to ins. per in. of length of specimen.
>
> When it was found that the elastic limit had been slightly exceeded, and a permanent stretch of from 0.03 to 0.06 in. in the 8-in. gage-length had taken place, the load was entirely removed; the micrometers were reset to 8 in. gage; and a second test was made with loads rising by equal increments up to a point slightly beyond the original elastic limit, and then returning by equal decrements to zero. So long as the specimen was in a state of overstrain, the plotting of the elongations for these cyclical loadings would form a so-called "hysteresis-loop," caused by the failure of the elastic forces within the piece to assert themselves promptly upon the removal of the external load. The width of these loops, under repeated loadings, would be reduced in proportion to the recovery from the state of overstrain. After the first cyclical loading, the bars were subjected to the temperature conditions described for the separate tests, and the cyclical loadings were repeated at varying intervals in order to follow the process of recovery, or to demonstrate its acceleration or its complete arrest.



Specimen 5, Extra Soft Steel.

Section, ⅝-in. by 2 ins. Area, 1.25 sq. ins. Elastic limit, 28,000 lbs. per sq. in. Permanent set in 8 ins., 0.05-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 2 h. after overstrain and 15 min. after steam-bath of 45 min.
4. 25 h. after overstrain and 23 h. after steam-bath.



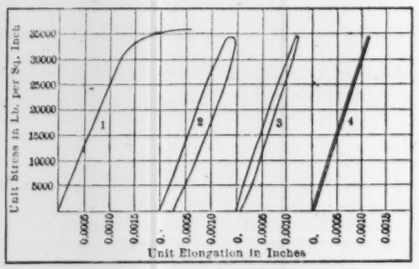
Specimen 6, Extra Soft Steel.

Section, ⅝-in. by 2 ins. Area, 1.25 sq. ins. Elastic limit, 28,000 lbs. per sq. in. Permanent set in 8 ins., 0.05-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 3 h. after overstrain and 1 h. after steam-bath of 45 min. (Loop is narrower than in Fig. 5. Time to cool.)
4. 26 h. after overstrain and 24 h. after steam-bath.

These experiments were carried on for three years, off and on, but the diagrams shown herewith (Figs. 1-3) are curves plotted from the behavior of 12 typical pieces, and are sufficient to indicate the result of the tests. The method of plotting the curves is obvious.

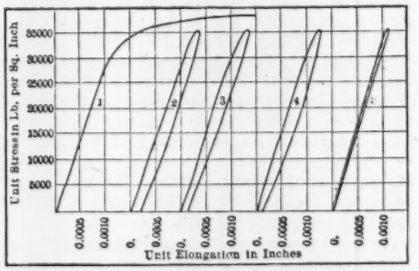
As a result of the tests the theory is confirmed that overstrained steel at moderate temperatures will return after a certain period has elapsed to a slightly higher elastic limit. This appears in each of the specimens from 1 to 4, in none of which was the temperature varied from that of a normal room, i. e., from 60° to 70° F. The exact effect of the high temperature after overstrain is not easily deduced. All the specimens, 5 to 8, recover their elasticity, but not at a noticeably quicker rate than those under a moderate temperature. That low temperatures, however, retard recovery is quite apparent from specimens 9 to 12 which, during their low temperature period show a marked loss in elastic qualities. This loss seems to increase with the time under low temperature, and its effect is prolonged even after the piece is removed to a more normal state. In course of time this effect is



Specimen 7, Mild Steel.

Round rod, 0.63-in. diameter. Area, 0.312-sq. in. Elastic limit, 30,000 lbs. per sq. in. Permanent set in 8 ins., 0.013-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 2 h. after overstrain and 30 min. after steam-bath of 45 min.
4. 24 h. after overstrain and 22 h. after steam-bath.



Specimen 8, Mild Steel.

Round rod, 0.63-in. diameter. Area, 0.312-sq. in. Elastic limit, 30,000 lbs. per sq. in. Permanent set in 8 ins., 0.015-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 24 h. after overstrain and 22 h. after steam-bath of 45 min.
4. 49 h. after overstrain and 47 h. after steam-bath.
5. 119 h. after overstrain and 117 h. after steam-bath.

FIG. 2. SHOWING THE ACCELERATING EFFECT OF HIGH TEMPERATURE (STEAM BATH) ON THE TIME OF RECOVERY OF STEEL FROM OVERSTRAIN.

counteracted by the higher temperature and the steel gradually resumes its elastic qualities and an elastic limit somewhat higher than it had originally.

Experiments along this same general line have also been carried on at Purdue University, and the following is taken from the report on the tests made by Mr. E. L. Hancock* before the Indiana Engineering Society, Jan. 18, 1907.

At first the attention was particularly directed to the recovery of steel (both carbon and nickel steel) from overstrain and the matter of the effect of extreme temperatures was not entered into to any great extent, though some of the pieces were immersed in boiling water before final testing. The pieces were tested in both tension and torsion. In this latter method a piece was first put under direct torsion and then under reverse torsion, thus producing the same effect on the fibers as if the pieces were first overstrained in tension and then tested in compression.

As a result of a series of tests extending over three years' time, Prof. Hancock came to the following conclusions:

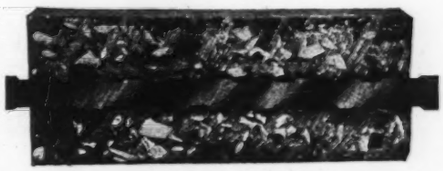
(a) That an overstrain in either tension or torsion destroys the elasticity of the material, but that this elasticity gradually returns when the piece is allowed to rest; the elastic limit becoming, in some cases, greater than its original value and the modulus of elasticity remaining the same as its original value. (b) That the elastic properties of the overstrained material are restored by immersion for a short time in boiling water. (c) That recovery is not aided by repeated impact from a light hammer. (d) Materials overstrained in either tension or compression lose their elasticity for stress of the opposite kind, but the elasticity is restored by rest. (e) The carbon steel seems to recover more quickly than the nickel steel. This, however, has not been shown conclusively by these tests.

It will be noticed that these results are practically the same as those deduced by Prof. McCaustland.

*Assistant Professor of Applied Mechanics, Purdue University.

AN EXAMPLE OF BOND BETWEEN STEEL AND CONCRETE.

The accompanying half-tone is taken from a photograph of a section made by sawing in two a block of concrete in which a corrugated bar of the Johnson type had been embedded. It indicates to a marked degree how close a mechanical bond can be obtained between steel and concrete. It might be added that this particular section was probably made for the especial purpose of illustrating the efficiency of the mechanical bond, and is only an example of the possibilities of the material when sufficient care is taken.



HOW THE NEW YORK CENTRAL ELECTRIC LOCOMOTIVES WERE PURCHASED AND TESTED.

A discussion on electric equipment of steam railways, at the last meeting of the New York Railroad Club,* was, rather naturally, the occasion for several extended references to the electric locomotives of the New York Central & Hudson River R. R.'s electric terminal service. Public discussion of the Bronx Park derailment on the Harlem division of that line, on Feb. 16, 1907, has quite causelessly entrained much derogatory statement about these electric locomotives. Mr. Frank J. Sprague, a member of the commission appointed by the railroad four years ago to develop plans for the electric terminal work, made an address, at the meeting referred to, in which he outlined the careful process by which the construction of these locomotives was fixed upon, and the service tests to which they were subjected, and pointed out the lack of all evidence for charging the electric equipment with contributory blame for the wreck, especially in view of the frequency of derailments on other railways in the last few weeks. The first part of this address contains some matter of general technical interest that has not before been known publicly:

*March 15, 1907.

Under date of May 5, 1903, the New York Central Electric Traction Commission, of which Vice-President W. J. Wilgus was Chairman, and of which I had the honor to be a member, issued preliminary specifications for electric locomotives to ten domestic and foreign manufacturers.

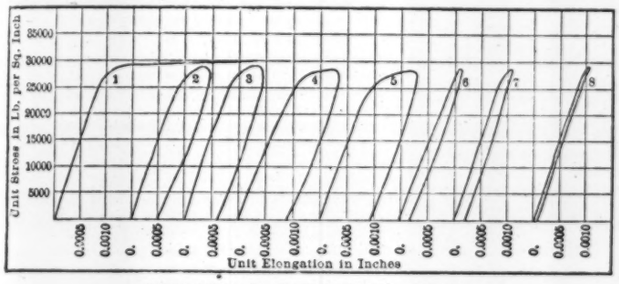
These specifications were accompanied by such facts, run sheets and other data as would permit bidders to intelligently formulate their own conclusions. While specific as to certain requirements, ample latitude for the exercise of individual judgment was given all manufacturers, as is indicated by the following brief extracts:

While certain essentials will necessarily govern the final selection of motors, it is the intention that all reasonable latitude will be extended to the manufacturers for elaborating any special plans which may be worthy of incorporation in the general plan. It is expected that the bidder will confer and work in conjunction with designers and manufacturers of steam locomotives of recognized standing, in designing the mechanical portion of the locomotive.

Should any bidder deem any requirement prohibitive in the free exercise of his best skill in the production of locomotives to fulfill the desired conditions, the Electric Traction Commission will appreciate any suggestions he may care to submit.

Both alternating and direct current motors will be considered, but in this connection it should be borne in mind that since all suburban service will be performed by trains having distributed motors, multiple-unit control will be used for all equipment.

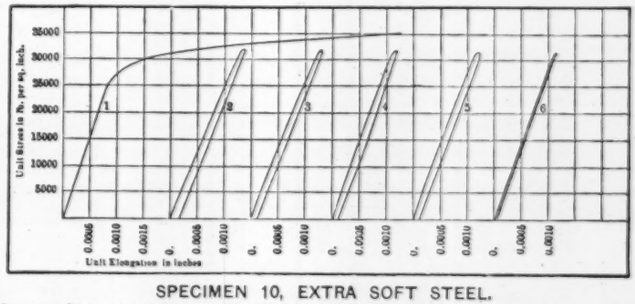
The locomotives were to handle a trailing load of 400 tons at schedule speeds, and to operate under the generally existing steam railroad track conditions, including curves with a minimum radius of 290 ft. A maximum



SPECIMEN 9, EXTRA SOFT STEEL.

Section, ⅝-in. by 2 ins. Area, 1.25 sq. ins. Elastic limit, 27,000 lbs. per sq. in. Permanent set in 8 ins., 0.024-in.

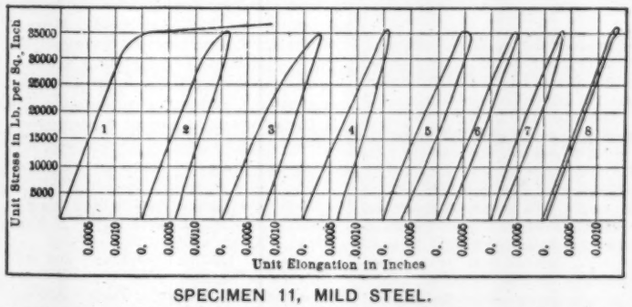
1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 48 h. after overstrain, 47 h. at freezing-temperature. (One hour interval.)
4. 2,092 h. after overstrain, 2,091 h. at freezing-temperature.
5. 2,136 h. after overstrain, 2,112 h. at freezing, 24 h. at moderate temperature.
6. 2,183 h. after overstrain, 2,112 h. at freezing, 71 h. at moderate.
7. 2,231 h. after overstrain, 2,112 h. at freezing, 119 h. at moderate.
8. 2,254 h. after overstrain, 2,112 h. at freezing, 142 h. at moderate.



SPECIMEN 10, EXTRA SOFT STEEL.

Section, ⅝-in. by 2 ins. Area, 1.25 sq. ins. Elastic limit, 27,500 lbs. per sq. in. Permanent set in 8 ins., 0.046-in.

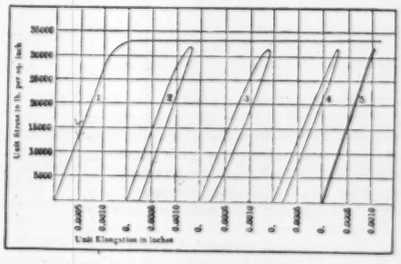
1. Stress-deformation curve.
2. 24 h. after overstrain, 23 h. at freezing temperature. (One hour interval.)
3. 168 h. after overstrain, 167 h. at freezing-temperature.
4. 361 h. after overstrain, 360 h. at freezing-temperature.
5. 4,728 h. after overstrain, 4,727 h. at freezing-temperature.
6. 4,848 h. after overstrain, 4,727 h. at freezing, 120 h. at moderate temperature.



SPECIMEN 11, MILD STEEL.

Round rod, 0.63-in. diameter. Area, 0.312-sq. in. Elastic limit, 30,000 lbs. per sq. in. Permanent set in 8 ins., 0.02-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 73 h. after overstrain, 72 h. at freezing-temperature.
4. 2,708 h. after overstrain, 2,707 h. at freezing-temperature.
5. 2,732 h. after overstrain, 2,708 h. at freezing, 24 h. At moderate temperature after steam-bath.
6. 2,754 h. after overstrain, 2,708 h. at freezing, 46 h. At moderate temperature after steam-bath.
7. 2,778 h. after overstrain, 2,708 h. at freezing, 70 h. At moderate temperature after steam-bath.
8. 2,801 h. after overstrain, 2,708 h. at freezing, 93 h. At moderate temperature after steam-bath.



Specimen 12, Extra Soft Steel.

Section, ⅝-in. by 2 ins. Area, 1.25 sq. ins. Elastic limit, 28,500 lbs. per sq. in. Permanent set in 8 ins., 0.047-in.

1. Stress-deformation curve.
2. 15 min. after overstrain.
3. 71 h. after overstrain, 70 h. at freezing-temperature.
4. 2,112 h. after overstrain, 2,111 h. at freezing-temperature.
5. 2,135 h. after overstrain, 2,111 h. at freezing-temperature, and 24 h. after steam-bath.

FIG. 2. SHOWING THE RETARDING EFFECT OF LOW TEMPERATURE (20°-30°F.) ON THE TIME OF RECOVERY OF STEEL FROM OVERSTRAIN AND THE EFFECT OF A SUBSEQUENT HIGH OR MODERATE TEMPERATURE.

speed of 75 mi. per hr. was required, of course on straight, sound track and with light loads.

Five months were allowed bidders, and proposals covering a large variety of locomotives were received from one foreign company and two American companies, the General Electric Co. and the Westinghouse Electric & Mfg. Co. The former included one bid for single-phase alternating-current motors of the repulsion type, which was very properly not seriously considered, but really recommended a new direct-current gearless type. The latter submitted no bid for alternating-current motors, a description only of gearless locomotives, and also recommended direct-current locomotives, but of a geared type.

The existing technical development, the high duty required and many specific local conditions, many of which were arbitrary and all of which are still practically unchanged, finally determined the adoption by unanimous vote of direct-current apparatus and the selection of locomotives narrowed itself down to the 2-8-2 gearless motor type now in use on the New York Central, and an 0-8-0 type equipped with geared motors.

The former locomotive, which was adopted, has a rigid wheel base of 13 ft., with four pairs of drivers on which is carried about 70% of the total weight and at each end there is a pivoted, spring-centered, two-wheel guiding pony truck, which extends the flexible wheel base to 27 ft. The drivers are 44 ins. in diameter, and the armatures are carried upon the axles, the weight of each axle unit not carried by springs being 12,745 lbs. There are no gears, and no armature or field bearings, but the bipolar field magnets are carried by, and form an integral part of the locomotive framing (the magnetic circuit being completed through the upper part of the side frame and a special bar carried above the motors) and hence are spring supported. The axles have a limited lateral movement, and the field magnets move independently of them. The center of gravity is about 44 ins. above the rail, higher in fact than in any electric locomotive of like diameter of drivers in this country. The resistance of the truck spring and friction-plate truck-bearing against deflection from the central position is such that when the guiding trucks are deflected on a curve they very largely, with proper superelevation and easing of gage, relieve the outer rail from lateral main driver pressure under normal conditions of service.

The other locomotive was of a type similar in many respects to the half unit common to single-phase alternating-current geared motor propositions, except that there were four instead of three pairs of drivers. The rigid wheel base was 15 ft. 6 ins. c. to c., and the drivers 54 ins. in diameter, somewhat increasing the lateral friction stress across the tops of the rails when on curves. The geared motors were independent of the locomotive frame, and carried entirely upon the axles, the two pairs being oppositely extended, making the center distance between the outer pairs 20 ft. 4 ins., that is, nearly 4 ft. longer than the rigid wheel base. The entire weight of the motors was not only supported by the axles, but there was undue pressure in their centers, and a large proportion was carried as dead weight. The armature revolutions for the same train speed were about 45% higher, and hence the gyroscopic effect much greater. There being no pony trucks whatever to help guide this locomotive around the curve, its tendency to go off on a tangent was particularly obvious, and the strain on any possible condition of track much more serious.

In an enterprise of such magnitude as that undertaken on the New York Central, the members of the Traction Commission, whether officers of the road or outside engineers, did not believe themselves justified in proceeding with final equipment except step by step, exercising supreme caution, and testing every possible development. Therefore, the machine as designed by the General Electric and the American Locomotive Companies having been selected, and its service requirements somewhat increased, in the latter part of November, 1903, a contract was entered into for the completion and test of one locomotive under rigid conditions, and for the completion of 30 machines, provided a test, to be made on a special experimental track some six miles long near Hoffman, N. Y., proved satisfactory. Nearly a year was given to develop this locomotive, the first machine was tested October 27, 1904, and a formal run was made on the 12th of November. This first locomotive, despite passing through a fire which necessitated partial rebuilding, and although subject to some of the early diseases incident to all new apparatus, has actually acquitted itself in a manner unsurpassed by any like apparatus ever built. During a period of two years, on an inferior track laid with only 80-lb. rail in gravel ballast, it has been run a total of 67,000 miles, under all sorts of conditions and loads, with operators of varied experience, and at speeds as high as 83 mi. per hr. on curves, and has never yet left the track.

A point that is not made clear in the above but deserves mention is that the pony trucks of the 2-8-2 locomotive were originally of a design similar to that used on steam locomotives, employing swing hangers to transmit the load to the truck. During the long period of test running the fact developed that, as built, the locomotive had an undesirably severe action on the track, producing lateral distortion of appreciable amount. This led to a re-designing of the trucks, including the substitution of a sliding bearing and a pair of opposed centering springs, in place of the hangers. The construction adopted (described somewhat more explicitly on p. 298 of our issue of March 14, 1907) has the merit of throwing a definite amount of curve-guiding work on the truck, so that the front pair of drivers has only a limited amount of guiding to perform.

THE INLAND WATERWAYS COMMISSION APPOINTED BY PRESIDENT ROOSEVELT.

President Roosevelt has just appointed an Inland Waterways Commission to prepare and report on a comprehensive plan for the improvement and control of the river systems of the United States. The duties of this commission, which consists of specialists in both engineering and economics, will include not only plans for the canalizing of rivers for the more efficient transportation of goods, but also recommendations on methods of preventing the floods which regularly destroy many lives and millions of dollars in property.

The President's letter to each member of the Commission is as follows:

The White House,
Washington, March 14, 1907.

My Dear Sir: Numerous commercial organizations of the Mississippi Valley have presented petitions asking that I appoint a commission to prepare and report a comprehensive plan for the improvement and control of the river systems of the United States. I have decided to comply with these requests by appointing an Inland Waterways Commission, and I have asked the following gentlemen to act upon it:

The Hon. Theodore T. Burton, Chairman; Senator Francis G. Newlands, Senator William Warner, the Hon. John H. Bankhead, Gen. Alexander Mackenzie, Dr. W J McGee, Mr. F. H. Newell, Mr. Gifford Pinchot, the Hon. Herbert Knox Smith. I will be much gratified if you will consent to serve.

In creating this commission I am influenced by broad considerations of National policy. The control of our navigable waterways lies with the Federal Government, and carries with it corresponding responsibilities and obligations. The energy of our people has hitherto been largely directed toward industrial development connected with field and forest and with coal and iron, and some of these sources of material and power are already largely depleted; while our inland waterways as a whole have thus far received scant attention.

It is becoming clear that our streams should be considered and conserved as great natural resources. Works designed to control our waterways have thus far usually been undertaken for a single purpose, such as the improvement of navigation, the development of power, the irrigation of arid lands, the protection of lowlands from floods, or to supply water for domestic and manufacturing purposes. While the rights of the people to these and similar uses of water must be respected, the time has come for merging local projects and uses of the inland waters in a comprehensive plan designed for the benefit of the entire country.

Such a plant should consider and include all the uses to which streams may be put, and should bring together and co-ordinate the points of view of all users of water. The task involved in the full and orderly development and control of the river systems of the United States is a great one, yet it is certainly not too great for us to approach. The results which it seems to promise are even greater.

It is common knowledge that the railroads of the United States are no longer able to move crops and manufactures rapidly enough to secure the prompt transaction of the business of the Nation, and there is small prospect of immediate relief. Representative railroad men point out that the products of the Northern interior states have doubled in ten years, while the railroad facilities have increased but one-eighth, and there is reason to doubt whether any development of the railroads possible in the near future will suffice to keep transportation abreast of production. There appears to be but one complete remedy—the development of a complementary system of transportation by water.

The present congestion affects chiefly the people of the Mississippi Vally, and they demand relief. When the congestion of which they complain is relieved, the whole Nation will share the good results.

While rivers are natural resources of the first rank, they are also liable to become destructive agencies, endangering life and property, and some of our most notable engineering enterprises have grown out of eff[orts] to control them. It was computed by Gens. Humphr[eys] and Abbott half a century ago that the Mississippi a[lone] swept into its lower reaches and the Gulf 400,000,0[00] tons of floating sediment each year (twice the amount [now] to be excavated in opening the Panama Can[al]), besides an enormous but unmeasured amount of earthy and soil matter carried in solution.

This vast load not only causes its channels to shoal and flood the lowlands of the lower river, but renders the flow capricious and difficult to control. Further, the greater part of the sediment and soil-matter is deposited of the most fertile material of the fields and pastures drained by the smaller and larger tributaries.

Any plan for utilizing our inland waterways should consider floods and their control by forests and other means; the protection of bottom lands from overflows, and uplands from loss by soil [erosion]; the physics of sediment-charged waters and the [chemical or other ways of purifying them; the construction of dams and locks, not only to facilitate navigation, but control the character and movement of the waters, and should look to the full use and control of our running waters and the complete artificialization of our waterways for the benefit of our people as a whole.

It is not possible properly to frame so large a plant as this for the control of our rivers without taking account of the orderly development of other natural resources. Therefore I ask that the Inland Waterways Commission shall consider the relations of the streams to the use of all the great permanent natural resources and their conservation for the making and maintenance of prosperous homes.

Any plant for utilizing our inland waterways, to be feasible, should recognize the means for executing it already in existence, both in the Federal Departments of War, Interior, Agriculture, and Commerce and Labor, and in the States and their subdivisions; and it must not involve unduly burdensome expenditures from the National Treasury. The cost will necessarily be large in proportion to the magnitude of the benefits to be conferred, but it will be small in comparison with the $17,000,000,000 of capital now invested in steam railways in the United States—an amount that would have seemed enormous and incredible half a century ago. Yet the investment has been a constant source of profit to the people, and without it our industrial progress would have been impossible.

The questions which will come before the Inland Waterways Commission must necessarily relate to every part of the United States, and affect every interest within its borders. Its plans should be considered in the light of the widest knowledge of the country and its people, and from the most diverse points of view. Accordingly, when its work is sufficiently advanced, I shall add to the commission certain consulting members, with whom I shall ask that its recommendations shall be fully discussed before they are submitted to me. The reports of the commission should include both a general statement of the problem and recommendations as to the manner and means of attacking it.

Sincerely yours,
Theodore Roosevelt.

Of the members of the Commission, Mr. Burton was Chairman of the Rivers and Harbors Committee of the House of Representatives in the last Congress; Senators Newlands and Warner are at present in the United States Senate; Mr. Bankhead retired from the last Congress after ten terms service; Gen. Mackenzie is Chief of Engineers of the U. S. Army; Mr. Newell is Director of the U. S. Reclamation Service; Mr. Pinchot is Chief Forester of the United States; Dr. McGee is an eminent anthropologist and lately in charge of the U. S. Bureau of Ethnology; and Mr. Smith is U. S. Commissioner of Corporations.

SNOW-LOAD ON ROOFS is the subject of some recent measurements by Mr. S. de Perrot, of Neuenburg, Switzerland. Where a heavy fall of snow was followed by thawing and freezing successively and then more snow, and thus in repeated cycle, a coherent laminar mass of snow and ice is formed on roofs, which is of remarkable density. Several such "snow" accumulations proved to have a weight of 36 to 38 lbs. per cu. ft. In these cases the thickness of the accumulated snow on the roof was 24 to 32 ins., thus producing a load of 70 to 100 lbs. per sq. ft. This is three or four times as much as is commonly assumed in calculation. Unfortunately the note from which we quote these observations (Schweizerische Bauzeitung, March 2, 1907) does not state the pitch of the roof surfaces in question. It is to be observed that the past winter has been a season of exceptionally heavy snowfall. On the Arlberg, it is reported, a total of 27 ft. of snow has fallen this winter.

MAMMOTH SHEAVE WOOD BLOCK.

We produce herewith a photograph of one of four double extra heavy 24-in. quintuple wood blocks which the W. W. Patterson Co., of Pittsburg, has recently completed for the Carnegie Steel Co. The height of this block over all is 4 ft. 7 ins., and total weight 640 lbs. The shackle is 2⅝ ins. in diameter, the head bolt 2¼ ins., the shackening bolt through the bottom of straps

A Mammoth Wood Block Recently Made by the W. W. Patterson Co., of Pittsburg.

1 in., and the sheave pin 1⅜ ins. This latter is of rolled steel, but all other metal is refined iron. The outside straps at each arm of the shackle are 3½ × ¾ ins.; the others, 3½ × ½ ins. The sheaves are each 15 × 3¼ ins. and are designed for a 2½-in manila rope.

NOTES FROM ENGINEERING SCHOOLS.

ARMOUR INSTITUTE OF TECHNOLOGY.—The monthly meeting of the Armour Branch of the American Institute of Electrical Engineers was held March 8. Mr. Chas. Jones, Chief Engineer of the Aurora, Elgin & Chicago Ry., made an address on "Some Experiences in Electric Railway Building," in which he noted the qualifications necessary in order to become a successful engineer.

UNIVERSITY OF ALABAMA.—A bill appropriating $400,000 for new buildings at the University has lately been signed by the Governor. An engineering building to cost $100,000 will be erected on the campus, as well as a new heating, lighting and power plant. A building to accommodate the Departments of Geology and Biology will also be built at a cost of $100,000.

HARVARD UNIVERSITY.—The ninth annual dinner of the Harvard Engineering Society was held Saturday evening, March 2, in the Harvard Union, 144 men, representing classes from 1855 to the present day, being present. Prof. I. N. Hollis, Chairman of the Division of Engineering, presided, and introduced the following speakers of the evening:—Mr. G. S. Rice, '70, Chief Engineer Rapid Transit Railroad Commission, New York; Mr. J. R. Worcester, '82, Consulting Engineer, Boston; Mr. Franklin Remington, '87, President Foundation Company, New York; Mr. F. L. Gilman, '95, Chief Engineer Western Electric Company, New York; Mr. J. A. Moyer, '99, Chief of the Computing Dept., General Electric Co., Lynn; Mr. H. M. Hale, '04, Assistant Engineer Rapid Transit Railroad Commission, New York.

A resolution was unanimously adopted to appoint a committee to report not later than Commencement 1907, on means for effecting a closer affiliation among Harvard men interested in engineering. It is proposed to establish a Harvard Engineering Society in New York City and possibly in other large engineering centers where the number of Harvard graduates interested in engineering may warrant it. The committee is as follows:—Chairman, Prof. L. J. Johnson; Messrs. G. S. Rice, F. W. Dean, J. E. Vaughan, F. L. Gilman, H. M. Hale, H. P. Forte.

FLOOD RECORDS OF A CENTURY WERE BROKEN last week at Pittsburg, Pa. In a remarkably sudden rise and recession of the waters of the Allegheny and Monongahela, the high water mark touched 36.6 ft., the highest previous records being 35.0 ft. in 1832 and 33.3 in 1884. The flood started on March 13, 1907, after a very hard and prolonged rain storm and continued to rise until March 16, when the record was reached. The loss of life is estimated at about 50 and the loss of property at $10,000,000, the latter being principally due to the shutting down of the big factories and steel works and to the damage to goods and fittings in the low-lying stores, hotels and theaters. The damage to shipping and railways adjacent to the rivers will run very high. For three days Pittsburg was in the main deprived of light, street-car service and telephones, and only one railway was enabled to get in and out of the city. The flood also passed down the Ohio Valley, but not to the record heights established last January. The high rainfall of last week, together with the heavy snow deposits in the mountains, are assigned as the cause. At Cincinnati two sections in the center of the Eighth St. viaduct collapsed as a result of the undermining of the foundations by the rising waters of the flood. These piers were founded on piles driven only through the loamy soil and not reaching into the solid clay bottom of the river. No one was upon the viaduct at the time of the collapse. This same structure was partly destroyed during the spring floods of 1897, apparently from the same cause.

THREE RAILWAY WRECKS occurred during the past week. A sleeper on the "Keystone Express" of the Pennsylvania R. R. jumped the track at Altoona, Pa., March 12, but no serious damage was done. The "Cannon Ball Express" of the Chicago, Rock Island & Pacific Ry. ran into an open switch at Cunso, Ark., March 15, and the entire train was ditched. Two trainmen were killed and seven other persons injured, one seriously. An open switch on the Grand Trunk Ry., at Bancroft, Mich., wrecked the "Atlantic Express" on March 16, five persons being seriously injured, two probably fatally.

THREE MINE ACCIDENTS, which caused the death of over 100 miners, occurred March 16, one in this country and two in Europe. An explosion of fire damp in a shaft of a coal mine at Kleinrossein, Germany, killed 67 men and seriously injured 12 others, while some 40 more are missing and are supposed to be buried in the wreckage. The parting of a cable at the Prussian Government's Gerhard mine, Saarlouis, Rhenish, Prussia, dropped a cage, loaded with 22 miners, several hundred feet to the bottom of a shaft and instantly killed the men. A fire damp explosion at the Greenough mine, Coeburn, Va., killed 11 miners. This is said to be the first explosion that has ever occurred in the Wise County coal fields.

SIX STEAMERS WENT ASHORE on the coast of the English Channel March 17, the boats being scattered from Plymouth to Dover, England. The passengers and crews of all the boats were rescued and numbered some 800 persons. The White Star liner "Suevic" grounded on the "Brandies Rocks," directly under the Lizard Light. The Elder Dempster Line steamer "Jebba" ran on the rocks under the cliffs at Prawle Point and the British steamer "Newstead" went ashore off Cuckmere, while the other three steamers grounded, one at Rye, one at Dunginess and one at Dover.

THE FIRST SPAN OF THE LONG BRIDGE at Washington collapsed March 13th during its demolition, and seven men who were working on it were thrown into the river. All were rescued with but slight injuries. The dismantling of this bridge was described in our issue of March 14, 1907.

THE CONSOLIDATION OF PITTSBURG AND ALLEGHENY City into a "Greater Pittsburg" may be consummated at once, the State Supreme Court having declared the second consolidation act constitutional. An earlier act was declared unconstitutional. The population of Pittsburg by the census of 1900 was 321,616, and of Allegheny 129,896. Using the arithmetic rate of growth as adopted by the U. S. Census Bureau, the population of the two cities in June, 1907, would be about 525,000. It is expected that the consolidation will take effect by or before April 1.

A PRIZE COMPETITION FOR DESIGNS OF CONcrete dwellings for suburban use is to be conducted by the Association of American Portland Cement Manufacturers, closing on April 1, 1907. The designs are to be for two classes: (a) Single or detached dwellings; (b) twin or semi-detached dwellings, and are to be rewarded with prizes varying from $40 to $200, a total of $925 being appropriated for this purpose. A pamphlet containing further information may be obtained from the Secretary of the Association, Land Title Building, Philadelphia.

THE SEPTIC TANK SUIT brought in one of the United States courts by the Cameron Septic Tank Co., of Chicago, against the cities of Saratoga Springs, N. Y., Madison, Wis., Lake Forest, Ill., and Monmouth, Ill., and the Allis-Chalmers Co. (on account of its disposal plant at West Allis), was decided on March 12 in favor of the five defendants. A review of the litigation was presented early in 1906 to the Illinois Society of Engineers and Surveyors by Mr. John W. Alvord, M. Am. Soc. C. E. His review was abstracted at length in Engineering News of Aug. 2, 1906.

AN INJUNCTION AGAINST THE CONSTRUCTION OF the Bronx Valley sewer has been asked by a taxpayer of White Plains, N. Y. The complainant alleges that the specifications under which bids are being asked are so framed as to prevent competition, and that the statute authorizing the sewer is unconstitutional in several respects. The complainant also asks the court to rule on the legality of diverting sewage from its natural drainage outlet into Long Island Sound through the divide between Bronx Valley and into the Hudson River. Mr. Frank N. Glover is Secretary and Mr. George R. Byrne is Chief Engineer (both of White Plains, N. Y.) of the Bronx Valley Sewer Commission.

THE POLLUTION OF LAKE CHAMPLAIN by pulp-mill refuse was made the subject of a hearing by Governor Hughes on March 15. The hearing was given at the request of a committee of the Merchants Association of New York. The lake is polluted by way of the Ausable River, through the discharge of wastes from the pulp mill of the J. & J. Rogers Co., above Keeseville. A representative of the mill stated at the hearing that $70,000 had been spent on experiments on the disposal of the wastes from the sulphite process, and that a disposal plant had finally been erected at a cost of $48,000. A lengthy report on the pollution of Lake Champlain by pulp and paper-mill refuse, by Prof. O. H. Landreth, was very fully abstracted in our issue of May 25, 1905. At the hearing mentioned, consideration was given to the pollution of Kayaderosseras Creek, a tributary of Saratoga Lake. No action on either hearing has yet been reported.

PERSONALS.

Mr. Webster Gazlay has been appointed Assistant Engineer of Board of Water-Works, for Louisville, Ky.

Mr. Egbert Douglass has resigned as Electrical Engineer for the Cataract Power & Conduit Co., Buffalo, N. Y.

Mr. W. A. Moore has resigned as Chief Train Dispatcher of the Buffalo, Rochester & Pittsburg Ry., to become Manager of the Telegraph Signal Co., of Rochester, N. Y.

Mr. R. E. Hunt, General Superintendent of the Norfolk & Portsmouth Traction Co., of Norfolk, Va., has been appointed Assistant to the President of the Utah Light & Railway Co.

Mr. H. L. Harmon, formerly President of the Kansas City Viaduct & Terminal Co., has been elected President of the Kansas City Terminal Railway Co., to succeed Mr. J. M. Egan.

Mr. James Bowdish, Trainmaster at Pasco, Wash., for the Northern Pacific Ry., has been appointed Superintendent of the Coeur d'Alene Division of the Spokane & Inland Empire system.

Mr. J. W. Walton, Superintendent of the Missouri, Kansas & Texas Ry., at Parson, Kan., has resigned, and accepted a similar position with the St. Louis & San Francisco R. R. He is succeeded by Mr. J. L. Walsh.

Mr. W. J. Dolan, formerly connected with the Remington Typewriter Co., and recently with the L. C. Smith Bros. Typewriter Co., of Syracuse, N. Y., has accepted a position with the Dayton Pneumatic Tool Co., of Dayton, Ohio. His headquarters will be at Pittsburg, Pa.

Mr. Geo. C. Saunders has resigned as Manager of the Philadelphia Office of the Osborn Engineering Co. of Cleveland, Ohio., and has opened an office at 186 Devonshire St., Boston, Mass., for the sale of iron and steel. He will make a specialty of bars for concrete reinforcement.

Mr. G. J. Bury has been appointed Assistant General Manager of the Canadian Pacific Ry.'s Western Lines, in charge of matters relating to Maintenance of Way and Operation. His office is at Winnipeg. Mr. J. E. Schwitzer has been appointed Assistant Chief Engineer of Western Lines, with office at the same place.

Mr. Lewis D. Thorpe has taken over the business formerly conducted by Freeman C. Coffin and Lewis D. Thorpe, Civil and Hydraulic Engineers. His office is

at 502 Cornhill Building., 46 Cornhill, Boston, Mass. He will make a specialty of water-works, water supply, water power, sewerage and sewage disposal.

Prof. George W. Bissel, head of the Mechanical Engineering Department and Vice-Dean of Iowa State College of Agriculture and Mechanical Arts, at Ames, Iowa, has been elected Dean of Engineering at the Michigan Agricultural College, Agricultural College, Mich. He will also act as Professor of Mechanical Engineering.

Mr. George L. Watson, Jun. Am. Soc. C. E., Consulting Engineer, Baxter Building, Philadelphia, Pa., has been retained by the Seaboard Cement Stone Co., of Holly Beach, N. J., as Consulting Engineer. This company makes a specialty of deep foundations, pits, tanks, reservoirs, and all kinds of reinforced concrete construction.

Mr. J. F. W. Bunsen has accepted a position with Muralt & Co., Engineers and Contractors, New York City, and has been placed in charge of their Southern Office at Charleston, S. C. Mr. Bunsen has had much experience in the design and erection of breweries, sugar refineries, spinning mills and oil refineries in Mexico, South America and Cuba.

Messrs. Louis Illmer and Walter Bohrer have formed a partnership under the name of Illmer & Co., Consulting Gas Engine Experts. They have opened an office at 310 Fourth National Bank Building, Cincinnati, Ohio, and will give special attention to oil and gas engine design and tests, and to plans, reports and supervisions of gas engine installations.

Read Admiral N. T. Endicott, Brig.-Gen. P. C. Hains and Mr. D. M. Harrod have resigned as members of the Isthmian Canal Commission. To fill these vacancies the President has reorganized the Commission as follows: Chairman, Mr. John F. Stevens; Major George W. Goethals, Corps of Engineers; Major David DuB. Gaillard, Corps of Engineers; Major William M. Sibert, Corps of Engineers; Civil Engineer, Commander H. H. Rosseau, U. S. N.; Chief Sanitary Officer, Col. Wm. C. Gorgas, Surgeon, U. S. A.; Head of the Department of Labor and Quarters, Mr. Jackson Smith. It is reported that upon the retirement of Mr. Stevens, who has resigned as Chief Engineer, Major Goethals will become Chairman, and that Ex-Senator J. C. S. Blackburn, of Kentucky, will be made a member of the Commission.

Mr. J. A. L. Waddell, M. Am. Soc. C. E., M. Inst. C. E., a member of the firm of Waddell & Harrington, Consulting Engineers, Kansas City, Mo., has recently been honored by the Russian Government in recognition of his services as Principal Engineer of the Trans-Alaska-Siberian Ry., by being elected a member of, and having conferred on him the insignia of the beneficent society established some time since by the Grand Duchess of Russia, Olga. The Order has been conferred upon only about thirty persons, and is given in recognition of services considered to be of great value to the government. It is interesting to note that nineteen years ago the Mikado conferred upon Mr. Waddell the Order of the Rising Sun in recognition of distinguished professional services rendered to the Japanese Government.

Obituary.

Guy D. Howe, a contractor of Evansville, Ind., died at his home in that place March 12, aged 53 years.

General Lewis B. Parsons, at one time President of the Ohio & Mississippi R. R., died at his home in Flora, Ill., March 16, aged 91 years. He served in the Federal Army during the Civil War, rising from the rank of Captain to Brigadier-General, and afterwards being brivetted Major-General.

Albert S. Gatschet, a scientist of the Ethnological Bureau of the Smithsonian Institute, Washington, D. C., died at his home in that city March 16, aged 75 years. He was born in Switzerland and studied at the universities of Berne and Berlin. After graduating he made a study of the dialects of his own country, and later was connected with the British Museum. In 1868 he came to the United States and began a study of the languages and dialects of the American Indian. From 1877 to 1879 he acted as Ethnologist of the U. S. Geological Survey, and later, when the Bureau of Ethnology was formed, he was made a member. He was granted the degree of Doctor of Philosophy in 1892 by the University of Berne.

Prof. Pierre Eugene Marcellin Berthelot, the distinguished chemist of Paris, and Secretary of the Academy of Sciences, died in Paris on March 18. Prof. Berthelot was born at Paris in 1827, and received his education at the College of Henry IV. He received his doctor's degree (Ph. D.) in 1854, and in 1860 was made Professor of Organic Chemistry at the Ecole de Pharmacie. In 1865 a Chair of Chemistry was established for him at the College of France, and he had lectured at that institution more or less regularly ever since. Prof. Berthelot's scientific work included researches into the phenomena of explosives and the generation of heat in chemical transformations. He published many books and was a constant contributor to the scientific press.

ENGINEERING SOCIETIES.

COMING MEETINGS.

IOWA ELECTRICAL ASSOCIATION.
April 18-19. Annual Meeting at Clinton, Iowa. Secy., L. P. Spinney, Iowa State College, Ames, Iowa.

THE AMERICAN RAILWAY ASSOCIATION.
April 24. Annual Meeting at Chicago. Secy., W. F. Allen, 24 Park Pl., New York City.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 22-24. Annual Meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 28-31. Semi-annual Meeting at Indianapolis, Ind. Secy., Mr. Calvin W. Rice, Engineering Societies Bldg., 33 West 39th St., New York City.

ALABAMA LUMBER MANUFACTURERS ASSOCIATION.—The next meeting will be held at Florala, Ala., April 9-11. Visits will be made to sawmill plants and to a wood turpentine plant in the vicinity. Mr. J. H. Eddy, Birmingham, Ala., is Secretary.

THE AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION.—The Committee in charge of Way Matters has sent out two circulars to the general managers and engineers of railway properties. The one asks for their experience with the phenomenon commonly called rail corrugations, while the other asks for results of tests and experience with concrete ties. The information thus obtained will be tabulated and filed for future reference.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The March meeting will be held at the Engineering Societies Building, 29 West 39th St, New York City, March 21, at 8.15 p. m. Mr. J. W. Lieb will give an illustrated lecture on "Vesuvius and Pompeii." Besides lantern slides made from photographs taken during the last eruption and slides showing the state of the Mechanic Arts in Pompeii, moving pictures of Vesuvius in eruption will be shown. This will be ladies' night.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The 217th meeting will be held in the Auditorium of the Engineering Societies Building, 33 West 39th St., New York City, March 29, at 8 p. m. Papers on "Lightning and Lightning Protection" will be read by Messrs. C. P. Steinmetz, E. E. F. Creighton and D. B. Rushmore. A special meeting of the Institute under the auspices of the High-Tension Transmission Committee will be held Friday evening, March 22, at 8 o'clock. Mr. B. A. Behrend will read a paper on the "Feasibility of Winding Large Generators for 20,000 Volts," and Mr. P. M. Lincoln will present one on "Motor-Generators versus Synchronous Converters with Special Reference to Operation on Long Distance Transmission Lines."

NEW YORK RAILROAD CLUB.—The regular monthly meeting was held March 15, at the Engineering Societies Building, New York City. This was the third annual electrical night of the club, and instead of having a technical paper read, several engineers of prominence gave talks on the subject of heavy electric traction. Mr. W. J. Wilgus, Vice-President of the New York Central & Hudson River R. R., the first speaker, referred to the tests, which lasted 2½ years, that had been carried on by his company to determine the adaptability of the electric locomotive for service in the Electric Zone. He stated that the tests had been highly satisfactory and that under no circumstances should electric traction be blamed for the recent wreck at Bronx Park, New York City.

Mr. Frank J. Sprague, who followed Mr. Wilgus, also discussed the recent wreck, and the safety of electric traction. He gave a review of how the New York Central's electric locomotives were purchased and tested. (See page 335 of this issue). To emphasize the fact that the Bronx Park accident should not be coupled with the electric system he gave a long list of accidents that had occured on the steam lines of this country since the accident on the Harlem Division of the New York Central & Hudson River R. R.

Mr. George Gibbs, Chief Engineer of Electric Traction, the Pennsylvania, New York & Long Island Ry., discussed the problems that must be solved in applying electric power to railways. In his opinion electric traction is well adapted to and economical in dense suburban traffic, terminal, tunnel and heavy grade work, but he thought that the time is far distant when the eletric would supplant the steam locomotive in trunk line service.

Mr. Walter C. Kerr, President of Westinghouse, Church, Kerr & Co., spoke on "The Conduct of Electrification Work." After briefly discusisng the conditions met with when substituting electric for steam power he named three ways in which a railway may undertake the work: (1), It may create a new department within itself to conduct it; (2), it may associate with it an already established competent organization of engineer-constructors as a department within the road; (3), it may employ engineers to make determinations, designs and specifications, and with their assistance let

method to have more desirable features and few[er] limitations than the other two.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held at the society's rooms in Chicago on [March] 6, two papers on concrete construction were presented. The first was by Mr. L. J. Hotchkiss, on "Some [Uses] of Concrete Construction," describing a number of [uses] of plain and reinforced concrete work built by [the] Chicago, Burlington & Quincy Ry. On the track [elevation] work, plain concrete is used for the bridge abutments on account of greater facility of construction under the existing conditions. Instead of steel bridges [over] the streets, there will be four spans of reinforced [girders] and floors, carried by the abutments and by three lines of steel columns and cross girders. Two girders [and] 7 ft. wide, are required for each track. For culverts and other minor openings in embankments rectangular [boxes] of reinforced concrete are used, from 4 × 4 ft. to 16 × [16] ft. The paper advocated the use of gravel in preference to crushed stone for the concrete, and also advocated a wet mixture, but it was pointed out that reinforcing bars should be so secured that the pouring of a wet concrete will not displace them. For coating the forms, lubricating compounds and black oil have been found in some respects superior to soft soap, as they do not dry quickly. The arrangement of concrete making plants for large pieces of work on railways was dealt with, as was also the performance of concrete work in cold weather.

In the discussion, Mr. O. P. Chamberlain spoke of designing a plain concrete retaining wall which required very little more material than the one of reinforced concrete described in the paper. As far as strength of concrete was concerned he considered a mixture of both stone and gravel would give better results than those made with either stone or gravel alone. Mr. T. L. Condron spoke of the occasional necessity of building very long walls without expansion joints, and instanced the partition walls in the Indianapolis filter beds. These are 350 ft. long, 12 ins. thick and 14 ft. high, made with a wet concrete and having so much reinforcement that the elastic strength of the steel will balance the tensile strength of the concrete. Although made without special means to secure waterproofing these walls are thoroughly water-tight under 10 ft. head. This work was described in Engineering News of April 26, 1906.

The next paper was a lengthy one on "How to Prevent Failure in Concrete Construction," by Mr W. Michaelis. It dealt specially with the necessity for proper and systematic building ordinances and regulations, with careful inspection of the work during its progress. It was also suggested that sample blocks should be prepared from the concrete as it is being used, the blocks being then subjected to compression tests in a testing machine. The blocks would be marked to indicate what parts of the work they represented. As to the quality of Portland cement, the author considered that its chemical properties cannot be improved, while its physical properties can only be improved by grinding it finer, which latter, however, would not be of any practical value. He advocated the use of a German iron-ore cement which is made of limestone and iron ore instead of limestone and clay; this cement was originally made for use in place of Portland cement in concrete exposed to the action of sea water. To what extent it has been used in structural work did not appear, but the author made some extremely broad statements as to its advantages over Portland cement. Indeed, he claimed that it contained twice the proportion of active material that exists in Portland cement (70 to 80% as compared with 30 to 40%), and that one barrel of this cement would contain as much actual cementing material as is now contained in three barrels of Portland cement.

In regard to reinforcement the author advocated for columns the use of "spiral reinforcement of the Considere type or expanded metal cylinders," bars of any kind being prohibited. For girders and beams he preferred trussed bars like the Kahn bar to single bars connected by stirrups, as the former represent units which cannot be so easily displaced in tamping the concrete in the forms.

Certain recent failures of reinforced concrete structures were dealt with as illustrating defects in methods of design and construction, and the author laid great stress upon the importance of exercising the greatest care in both design and construction. The centering for one floor should not be built upon the floor below, but supported by inclined posts to distribute the load upon the columns and girders. If the former is used, however, all centering should be left in place until the concrete of the roof or top floor has set and become hard; even then the removal should be commenced at the top of the building, so that a comparatively fresh floor will not have to sustain the load of several floors above it, with their centering. In conclusion, the author stated his opinion that under present conditions "concrete is the building material of the widest possibilities and yet the unsafest to use." As the reading of the second paper was not concluded until 11 p. m. there was no time for discussion, but it is expected that written discussions will be presented.